Faculty of Educational Sciences

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ENGAGING SECONDARY SCHOOL STUDENTS IN SCIENCE LEARNING THROUGH A MASSIVE OPEN ONLINE COURSE (MOOC)

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DOCTORAL DISSERTATION

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ABSTRACT

This doctoral study is an investigation of secondary school students' situational engagement in a science Massive Open Online Course (MOOC) drawing on flow theory. The main goal in this doctoral study is to describe and understand the context-dependent feature of situational engagement in an online learning environment. Four research questions were asked. First, how is secondary students' online learning situational engagement predicted by the factors of self-efficacy, feeling-related interest, and value-related interest? Second, what influence do time and course contexts have on students' level of situational engagement in an online learning environment? Third, what are the gender and grade differences in lower and upper secondary schools in terms of student's reported situational engagement and related variables in a science MOOC environment? Fourth, what are the aspects and themes that impact students' situational engagement in a science MOOC environment? Based on these research questions, fifteen hypotheses were formulated and tested.

Situational engagement in this study was conceptualized using the flow theory, under which interest, skills, and challenges are the preconditions. Using the conceptualization, a short MOOC on the topic of sustainable development and energy consumption was developed for a Finnish secondary school science class. A mixed-method approach was used to analyze research data including a survey questionnaire and a semi-structured interview. The data were collected in two metropolitan areas of Finland in 2018-2019. The survey participants were 193 secondary school students from three public schools, and five students participated in a semi-structured interview. The SPSS statistical software package was used for the analysis of survey data. Specifically, hierarchal regression analysis was performed to examine factors that predicted students' situational engagement, and one-way repeated ANOVA was applied to see if there are fluctuations in the levels of situational engagement across all measurement points. In addition, a series of independent sample t-test (two-tailed) were conducted to compare gender and grade differences in those variables. In analysing the interview data, a hybrid process of inductive and deductive thematic analysis was applied focusing on the inductive approach as proposed by Fereday and Muir-Cochrane (2006).

Research findings are as follows. First, while self-efficacy and value-related interest are the predictors of a MOOC learning situational engagement, feelings-related interest failed to influence on the students' level of situational engagement. Second, students reported the significantly different levels of situational engagement across all measurement points as well as different situations. Specifically, situations in which a teacher was explaining a concept/model seemed to be the most engaging situation to students. Based on this result, it proved the context-dependent feature of situational engagement in online learning. In terms of gender, significant differences were found only on self-efficacy in favouring boys. In grade-wise, significant differences were found on self-efficacy in favouring lower secondary school students, and on science knowledge in favouring upper secondary school students. Finally, the interviews revealed additional factors impacting on the situational engagement. Of those factors, interest in science, degree of autonomy, teachers and teaching style, and quality learning materials were among the factors that are important to online learning situational engagement. The significance of the study that contributes to the literature of situational engagement and the suggestions for future work are discussed toward the end of this study.

Keywords: situational engagement, flow theory, sustainable development, science MOOC; secondary school students

TIIVISTELMÄ

Väitöskirjassa tutkitaan toisen asteen opiskelijoiden tilannekohtaista sitoutumista (situational engagement) oppimiseen avoimella verkkokurssilla (Massive Open Online Course-MOOC) tukeutuen flow-teoriaan. Väitöskirjassa esitettiin neljä tutkimuskysymystä: 1. Millä tavalla minäpystyvyys sekä tunteisiin ja arvioihin liittyvä kiinnostus luonnontieteiden opiskleua kohtaan selittävät verkkokurssilla oppimiseen, tässä MOOC, sitoutumista? 2. Vaikuttaako avoimen verkkokurssin pituus ja sisältö oppimiseen sitoutumiseen? 3. Millä tavalla oppilaansukupuoli ja luokkataso ovat yhteydessä tilannekohtaiseen sitoutumiseen verkkokurssilla oppimisessa? 4. Mitkä avointen verkkokurssien ominaisuudet ovat yhteydessä tilannekohtaiseen sitoutumiseen verkkokurssilla oppimisessa? Näihin tutkimuskysymyksiin perustuen muodostettiin ja testattiin 15 hypoteesia. Tämän väitöskirjan päätavoite on kuvata ja ymmärtää verkko-oppimisympäristöjen kontekstisidonnaisia ominaisuuksia, joilla on yhteys tilannekohtaiseen oppimiseen sitoutumiseen. Tässä tutkimuksessa tilannekohtainen oppimiseen sitoutuminen käsitteellistettiin tukeutumalla flow-teoriaa, jonka reunaehtoja ovat tilannekohtainen kiinnostus, oppijan taidot ja oppimiseen liittyvä haaste. Väitöskirjaa varten rakennettiin toisen asteen oppimiseen soveltuva lyhyt avoin verkkokurssi, joka käsitteli kestävää kehitystä ja energian kulutusta. Verkko-oppimisessa käytätettiin erilaisia opetusmenetelmiä, jotta tutkimuskysymyksiin saataisiin vastauksia. Tutkimuksen aineisto perustui kyselyllä kerättyyn materiaaliin ja kvalitatiiviseen materiaaliin, joka kerättiin puoli-strukturoiduilla haastatteluilla. Aineisto kerättiin kahdella kaupunkialueella vuosina 2018-2019. Kyselyyn osallistui 193 toisen asteen opiskelijaa ja haastatteluihin osallistui viisi opiskelijaa. Kyselyiden materiaalin analysointiin käytettiin SPSS-ohjelmapakettia. Yksityiskohtaisemmin käytettiin hierarkkista regressioanalyysiä, jotta saatiin selville mitkä tekijät ennustavat opiskelijoiden oppimiseen sitoutumista erilaisissa tilanteissa. Yksisuuntaisella varianssianalyysillä pyrittiin saamaan selville onko erilaisilla tilanteilla yhteys oppimiseen sitoutumiseen. Lisäksi käytettiin kaksisuuntaista t-testiä, jotta pystyttiin vertailemaan sukupuolen ja luokkatason yhteyttä oppimiseen sitoutumiseen. Haastattelumateriaalin analyysissä käytettiin induktiivisen ja deduktiivisen sisällönanalyysin yhdistelyä, , kuten Fereday ja Muir-Cochrane esittävät (2006).

Analyysien perusteella voidaan tehdä useita päätelmiä. Ensinnäkin, minäpystyvyys ja arvoihin liittyvä kiinnostus ovat positiivisia prediktoreita tilannekohtaiselle oppimiseen sitoutumiselle. Tuntiesiin liittyällä kiinnostuksella ei ollut yhteyttä tilannekohtaiselle oppimiseen sitoutumiselle. Toiseksi, oppilaiden tilannekohtainen oppimiseen sitoutuminen vaihteli kuudessa eri tilanteessa, missä aineistoa kerättiin. Tilanteet vaihtelivat sen mukaan, mihin opetusmenetelmään tukeuduttiin.. Erityisesti tilanteet, joissa opettaja selosti käsitettä / mallia olivat kaikkein sitouttavimpia. Tulosten perusteella kontekstisidonnainen ominaisuus verkko-oppimisessa sitouttaa oppilaita oppimaan Sukupuoleen liittyviä merkittäviä eroja löydettiin ainoastaan minäpystyvyyden osalta: poikien minäpystyvyys oli tyttöjä

suurempaa. Luokka-asteen suhteen merkittäviä eroja löytyi minäpystyvyydessä: minäpystyvyys oli korkeampi alemman luokan oppilailla. Ylemmän luokan oppiminen oli alemman luokan oppilaiden oppimista korkeampaa. Haastattelut paljastivat lisää tekijöitä, joilla oli yhteys tilannekohtaiseen oppimiseen sitoutumiseen. Näistä kiinnostus luonnontiedettä kohtaan; tietyn asteisen autonomian omaaminen; opettajan opetusmenetelmä; ja laadukkaat oppimateriaalit olivat yhteydessä tilannekohtaiseen sitoutumiseen verkossa oppimiseen. Tutkielman sovelluksia ja uusia tutkimuskohteita käsitellään kunkin asian yhteydessä.

Avainsanat: tilanteellinen osallistaminen, flow- teoria, kestävä kehitys, tiede MOOC, toisen asteen opiskelijat

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I would like to end with a quote from an anonymous thinker, which continuously inspired me, “*The dream is free, but the hustle is sold separately*”.

CONTENTS

1 INTRODUCTION

1.1 Background of the study

Students' engagement in learning is increasingly viewed as an indicator of successful classroom instruction and valued as an outcome of school-improvement activities. However, politicians and researchers alike are worried about students' lack of engagement in science, technology, engineering and mathematics (STEM) subjects. For example, the European Commission's Horizon 2020 Work Programme (European Commission, 2016) emphasizes that science education should engage young people better in science learning. Similarly, in Australia, a study revealed a continuing decline in interest in mathematics and science learning among high school students. For example, between 1992 and 2012, the number of twelfth grade students in Australia increased by 16%, while their general interest in science and mathematics-related subjects decreased by 5% to 10% (Kennedy et al., 2018). While there are fewer students willing to choose STEM related fields (i.e., science) as their career aspiration, the labour market demand in most STEM fields is expected to increase dramatically, by between 8% and 12%, in the foreseeable future, as predicted by Price Waterhouse, Coopers, & Lybrand (2015). In Finland, according to the newest 2018 Programme for International Student Assessment (PISA) results (Organisation for Economy and Cooperation and Development [OECD], 2019), students' academic performance in mean reading, mathematics and science have been declining since 2006. Especially in science, the 2018 result was significantly lower than that in PISA 2015. Because of this situation, educators and stakeholders are passionate about enhancing students' engagement and interest in STEM subjects. For example, in the U.S., to combat problems such as debilitated capabilities in technologies and scientific innovation (National Science Board [NSB], 2014), it was suggested that the STEM pipeline should be strengthened by enrolling and graduating more students from university STEM programmes. In addition, this goal is clearly stated in the Next Generation Science Standard (NGSS) (NGSS Lead States, 2013, p.1) by increasing the number of individuals entering STEM fields, the U.S. can "...continue to innovate, lead, and create jobs of the future." This is also relevant to online STEM learning, as online learning is now being provided almost everywhere. In the academic world, it is also important to analyse previous studies on student engagement, which will provide useful information on real-world practices.

Engagement is one of the most discussed topics in education (Kahu, 2013). In academic research, *engagemen*t was even described as "...the holy grail of learning" (Sinatra et al., 2015, p.1). According to the U.S. National Academies of Sciences (NAS, 2018), student engagement in learning was defined as the relationship between the student and the elements of the learning environment (e.g., the teacher, student's peers, instruction, activity, learning materials and curriculum) (NAS, 2018). Previous studies have demonstrated that students engaged in learning are more likely to show a higher level of self-regulation (Lee et al., 2014); spend more time on learning tasks (Ainley et al., 2002); apply effective learning strategies (Krapp, 2000; Schiefele, 1991, 1999); and acquire better learning concepts (Cordova et al., 2014). Studies about the critical components (such as engagement) of online learning in K-12 schools pale in comparison with those about the traditional leaning environment. Some argued that one reason would be the characteristics of K-12 learners: they tend to be less autonomous and motivated than higher education students, and In addition, the existing research frameworks are more related to the higher education environment (Borup et al., 2014). Another reason may be because online learning was used more frequently for college students (i.e., the Massive Open Online Courses). Studies about interest and engagement that focus only on the formal learning environment have their own limitations, as they lack understanding of the constructs in out-of-school learning activities (Arnone et al., 2011) such as Massive Open Online Courses (MOOCs). More studies about such contexts may broaden our knowledge in terms of how constructs like situational engagement and interest are maintained and developed across a timespan, which would help to address pupils' study difficulties in the classroom. In addition, compared with a traditional learning arena such as a science classroom, online learning provides rich extra-curricular activities and material for school learning. Developing web-based science labs and activities and integrating information and communication technology (ICT) into science teaching is the trend in science education, and it fits more individual needs (Sun et al., 2008).

1.2 The aim of this study

Although research on students' situational engagement in the classroom environment has gained increased attention recently (i.e., Lau & Roeser, 2002; Schneider et al., 2016), few authors have focused on situational engagement in an online learning environment. Although existing studies agree that engagement is a changeable, malleable experience that occurs over time, little attention has been paid to how students experience science learning situations (Fredricks & McColskey, 2012). Thus, measuring engagement in real situations (e.g., the experience sampling method) (Csikszentmihalyi & Schneider, 2000; Hektner et al., 2007) sheds light on students' online science engagement and how different contexts affect it. Drawing on previous studies that have assessed situational engagement/optimal learning moments via flow theory and theories about interest such as personal object interest (POI) (i.e., Hidi & Renninger, 2006; Inkinen et al., 2019; Krapp, 2007; Schneider et al., 2016), this study aims to measure secondary school students' online learning situational engagement in the context of flow theory.

In general, student engagement in learning refers to the relationship between the student and the elements of the learning environment, such as the teacher, a student's peers, instruction, activity, learning materials, and curriculum (NAS, 2018). Engagement is a multidimensional construct that includes three dimensions: behavioural engagement, focusing on participation in academic, social, and co-curricular activities; emotional engagement, focusing on the extent and nature of positive and negative emotions, like interest in learning; and cognitive engagement, focusing on students' level of investment in learning when they meet a challenge in learning (Marks, 2000). Engagement is often understood as student-active behaviour.

For example, the definition of inquiry-based science learning includes an idea that inquiry as an activity engages students in learning (Minner et al., 2010). The focus of this study is on emotional and cognitive engagement in the context of flow theory (Csikszentmihalyi, 1990) as described below.

The main aim of this study was to measure students' situational engagement in a science MOOC on the topic of sustainable development and energy efficiency and investigate the factors that may be associated with it. To that end, a survey was conducted using a tailored Finnish Massive Open Online Course (MOOC) from a local university. Therefore, the specific aim of this study is threefold. First, it is to investigate the relationships between *self-efficacy* (which refers to one's self-evaluation of abilities to arrange, execute and keep behaviour to achieve certain goals), *science attitude* (which refers to one's perceived enjoyment and the value of doing science), *achievement* (based on a science knowledge test), and situational engagement in online science learning. Second, it is to investigate the effect of time and contexts of the course on students' level of situational engagement. Third, it is to investigate individual differences such as gender and grade on all the variables studied. Flow theory was applied for the purpose of conceptualizing and understanding situational engagement in the context of online science learning. In this study, situational engagement in the context of flow theory (Csikszentmihalyi, 1990; Schneider et al., 2016) was approached through three pre-conditions: interest, skill, and challenge. A mixed method design was applied to test a conceptual model of situational engagement, and to examine interrelationships between the variables and how time and contexts of study affect students' level of online learning engagement. Accordingly, a framework that consisted of predictors of situational engagement and individual differences was proposed and tested via a mixed method approach. Several factors related to situational engagement were investigated, and the level of situational engagement was compared during the MOOC, based on several situations. To measure situational engagement during the MOOC, a set of pop-up questions was administered in several situations at crucial times during the MOOC. In addition, a semi structured interview was conducted after the MOOC, to evaluate students' experience of engagement and online learning preferences. Results regarding factors associated with situational engagement and how it contributes to both academic achievements and future MOOC planning were also discussed according to results and in the discussion chapter.

1.3 Context of MOOC

In this study, the purpose was to measure Finnish students' situational engagement in a short MOOC and to explore factors related to engagement in situations. A short science MOOC in the field of sustainability and energy efficiency was utilized for such purpose. Topics like environment and sustainable development are deeply rooted in the Finnish mind-set, and this was constantly emphasized at the national policy level, such as in the national core curriculum. For example, the 2014 edition of the national core curriculum listed "*participation, involvement and building a sustainable future*" among the crucial transversal competencies for students to cope with 21st century challenges (Finnish National Board of Education [FNBE], 2014, p.55). In addition, a similar concept was emphasized ten year earlier, when they suggested "*Responsibility for environment, well-being and sustainable future*" as one of the focus of cross-curricular teaching themes (FNBE, 2004, p.36-42). Globally, students' interest and engagement in the classroom environment has been extensively studied (Sinatra et al., 2015), but not in the context of online learning such as in a MOOC. Therefore, in this study, I sought to contribute to this layer of knowledge. An experts' MOOC lecture on the topic of sustainable development and energy efficiency was used in this study, and its implementation into a Finnish secondary school course, aimed at measuring the students' engagement across different situations. The learning materials (i.e., course videos, quizzes) were created by the National Centre of Natural Sciences and Mathematics Centre (LUMA) of the University of Helsinki, but the course was redesigned and constructed by the research team involved in this study. A detailed description of how the MOOC was developed step by step was presented in section 3.2.

1.4 Research questions

Taken together, four main research questions drive this study. The first one was on the effect of variables such as self-efficacy (SE), feeling-related interest, and value-related interest in various situational engagements. Although the effects of the motivational factors on learning engagement have been investigated extensively, few studies have paid attention to the effect of the motivational factor of self-efficacy, interest on situational engagement. Thus, one important aim of this study is to explore the relationships between self-efficacy, personal interest, and situational engagement. The focus of the second question was on the 'situations' of engagement, such as how different course contexts/activities affect students' self-reported level of situation. The third question assessed the individual differences on all the factors studied. Finally, a question was asked about factors that students believed to be important in situational engagement.

- *How is secondary students' online learning situational engagement predicted by the factors of self-efficacy, feeling-related interest, and value-related interest??*
- *What influence do time and course contexts have on students' level of situational engagement in an online learning environment?*
- *What are the gender and grade differences in the lower and upper secondary schools in terms of student's reported situational engagement and related variables in a science MOOC environment?)*
- *What are the aspects and themes that affect students' situational engagement in a science MOOC environment?*

1.5 Structure of the study

Overall, the present study consists of six parts. The first part concerns the theoretical background and hypothesis development. To begin with, an in-depth literature review of relevant studies was conducted based on which the factors and trends of online learning engagement were summarized. In the literature review, terms such as *online learning engagement* and *situational engagement* were defined, which was followed by introducing central concepts and how they are interrelated and organized for the purpose of this study. Situational engagement as a core concept was then introduced, and the literature on such topics was reviewed in relation to flow theory. In addition, Hypotheses based on the literature review were proposed, and the conceptual framework were built on the research questions and hypotheses. The second part was entitled *the present study*. Basically, it introduces the study based on three sections: a brief description of the conceptual framework, a section called *context of the study* featuring sections such as MOOC development (learning materials development; instrument development) and MOOC pilot testing, and a summary of all research questions and hypotheses. The third part is methodology that presents how data were collected, who the participants were, the instruments that were used, and how data were analysed. It is worth noting that the data analysis section was divided into quantitative and qualitative approaches, which were described separately. The fourth part concerns the results in which the research findings were presented according to the research questions and hypotheses. Right after the results part is the discussion (which concerns how the results of this study relate to previous studies), the importance and contribution of this study, and a discussion about the limitations. The sixth chapter concerns the conclusion, which not only summarizes the whole study but also goes further by providing suggestions for future studies. There is also a chapter on reliability and research ethics in which reliability, validity and ethics issues were discussed in detail.

2 THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

The key terms used in this study are *online learning engagement, situational engagement, self-efficacy, attitude, interest, skills, and challenges*. For the purpose of this study, the concept of engagement in a broader sense was first introduced, followed by a similar yet different term: situational engagement. Although *situational engagement* (in later parts also *situ-engagement*) is the core concept of this study, the literature review was conducted first with definitions followed by a study on engagement. This was because situational engagement was a sub-theme of engagement in general. In addition, discussion on the general concept of engagement first helps the reader to understand about situational engagement better. Preconditions of situational engagement will be introduced separately, and their connection with online learning engagement will be reviewed. Specifically, flow theory and interest were described and explained, especially on how they contribute to the study in question. Next, a review of factors that are associated with engagement will be conducted, such as self-efficacy, attitude and academic performance towards learning. In addition to predictors and properties of situational engagement, literature regrading individual difference of learning engagement across various settings were also reviewed, mentioning the theory of gender similarities. Finally, based on the literature review and along with the research questions and hypotheses that emerged, a conceptual framework was formed for this study. The conceptual framework was presented collectively in section 3.1 *The Present Study* (see Figure3-1 for details).

2.1 Engagement in learning as a concept

2.1.1 Definition of engagement

Engagement as a concept has existed in the literature for more than 80 years, with constructs and definitions changing constantly. One of the early mentions of *engagement* can be found in the work of educational psychologists such as Ralph Tyler (1930s) who defined *engagement* as time on a (learning) task, and later educationalists who mentioned "quality of effort" as a booster of better performance, and to the most referenced definition today that pertains to student engagement is "as quality of effort and involvement in productive learning activities in a learning test" (Kuh, 2009, p.7). According to a literature review by Yang and colleagues (2018), the definition of engagement by Kuh (2003) was generally applied in online engagement study. Kuh defined engagement as "the time and energy students devote to educationally sound activities inside and outside of the classroom, and the policies and practices that institutions use to induce students to take part in these activities." Student engagement also refers to a student's willingness, need, desire and compulsion to participate and succeed in the learning process (Bomia et al., 1997). In addition to time, energy, and emotions, learning strategies were also mentioned in some definitions of engagement. For example, Lau and Roeser (2002) defined engagement with regards to positive emotions, paying attention and use learning strategies, and time spend on a task or a domain. Some extended the general definition of engagement, ascertaining that student engagement not only deals with the management of time, effort and resources, but also institutional efforts in enriching students' learning experiences and performance (Trowler, 2010). One classic interpretation of engagement was from Fredricks and his colleagues (2004) who classified engagement as consisting of behavioural engagement, emotional engagement and cognitive engagement. In the academic world, these engagement dimensions (behavioural, emotional, and cognitive) echoed on-task behaviour, interests or attitudes, and motivation and self-regulated learning separately (Yang et al., 2018).

In general, there are component aspects of engagement and domain-specific aspects of engagement. The componential perspective of engagement characterized engagement into four parts, namely, behavioural engagement, emotional engagement, cognitive engagement (Fredricks et al., 2004), and one was added to the model later, agentic engagement (Reeve & Tseng, 2011). In terms of domain-specific aspects of engagement, Sinatra et al. (2015) argue that in science engagement, motivation, emotional factors and how they affect one's content choice should be emphasized in research. Current studies on science engagement tend to treat engagement as a mediator, testifying to its association with factors such as motivation, interest (i.e., Patall et al., 2016; Pugh et al., 2010) and outcomes such as science achievement (Lau & Roeser, 2002). Yet. some worried about the chaos of defining and measuring engagement (i.e., Sinatra et al., 2015), and they showed a concern about the misuse of concepts which may further misguide the measurement of engagement, such as how to measure situational engagement without disturbing learners' learning flow. Although there are several definitions of engagement, there is still a dearth of conceptualization of the term '*online learning engagement*' (Yang et al., 2018). After a critical review of the previous literature on engagement, Yang and colleagues (2018) proposed a definition of *students' online learning engagement* (SOLE): SOLE refers to students' devotion of time, energy, value, learning strategy or even creative thinking in e-learning environments and the motivational and action processes elicited. They argue that students who are engaged have the potential for positive behaviour and a sense of commitment, but this does not necessarily promote positive learning outcomes (e.g., higher grades) but it may foster personal well-being. Thus, they interpreted engagement as both a situation and a process that are measurable, but not necessarily results-oriented (Yang et al., 2018). This definition of engagement has guided my work in this study, as attention was paid to the factors related to engagement and situational engagement. Nonetheless, in this study, special emphasis was placed on the importance of what led to engagement and how to understand the engagement in a given task.

The discussion of online learning, or e-learning began early in the 1960s (Nicholson, 2007), but there is still no agreed definition on such terms. Some refer to online learning as the 'access to learning experience via the use of some technologies' (Moore et al., 2011, p.130) while others state that online learning is the updated version of distance-learning education, with improved availability of educational resources (for example, Benson, 2002; Conrad, 2002). Besides accessibility, research on online learning also has emphasized flexibility, convenience, and the opportunity to promote interactions between people (Hiltz & Turoff, 2005; Oblinger & Oblinger, 2005). In this study, online learning has been defined in a broader sense: online learning refers to learning that uses a certain technology, including the Internet, to facilitate access to educational resources. It should also include interaction and collaboration or working with common documents through the net. Online learning is referred to as learning that takes place partially or entirely through the Internet (Lowenthal et al., 2009; Oblinger, & Oblinger, 2005). Thus, this definition excludes print-based classroom education and traditional distance education that uses radio, TV broadcasts and videoconferencing with no online component. Though the focus of this study is on engagement in situations, it is also worth noting that the item *situational engagement* originally emerged from engagement. To understand situational engagement, the relevant study on engagement and theories is important, as it formed the theoretical basis of situational engagement. This also explains why study on engagement was first summarized from a broader perspective, then situational engagement come next, as described in the next few sections.

2.1.2 Previous work on learning engagement

In academic research it has been shown that students are more engaged when they are interested in their work and more likely to persist in staying on their tasks despite challenges and obstacles, and they take visible delight in accomplishing the work goals (Fredricks et al., 2004; Reeve et al., 2004). Much research has been done on engagement, especially the antecedents and outcomes of engagement in traditional classroom settings. Such antecedents include motivational factors such as autonomy, interest and self-efficacy (Skinner et al., 2009), learning-community participation (Pike et al., 2011), school-level factors such as flipped classrooms (Gilboy et al., 2015), technological factors such as gamification (Cronk, 2012), teacher support (Klem & Connell, 2004), and peer interaction, class structure, task characteristics and personal needs (Fredricks et al., 2004). Such outcomes of engagement include learning achievement and drop-out rate (Fredricks et al., 2004; Steele & Fullagar, 2009), learning satisfaction (Wefald & Downey, 2009), complex problem-solving skills (Eseryel et al., 2014), study persistence (Kuh et al., 2008), and so on.

Due to the constant changes in society and development of learning technology, attention to study on online learning engagement is increasing. The focus of research has also changed accordingly from study focusing on e-learning to the blended learning model and to the ever-debatable Massive open online Courses (MOOCs) (Yang et al., 2018). Furthermore, various theories were applied in engagement-related studies. For example, learning theories such as constructivism, self-directed learning, self-regulated learning; motivational theories such as self-efficacy, autonomy, interest; or using complex frameworks like Pittaway's engagement framework (Pittaway, 2012) or Fredricks' three-dimension engagement framework (Fredricks et al., 2002). Interestingly, what and how scholars measure engagement has also been changing in response to theories and the technology revolution. For instance, according to a recent literature review, mixed methods research has gained popularity over the past ten years, with a common practice being to "apply quantitative data to first-step investigation, then utilize a qualitative approach (e.g., content analysis or video analysis) for deep reasoning and understanding" (Yang et al., 2018, p.15). This literature review, however, failed to mention another interesting direction of recent research on engagement—situational engagement. In most cases, either for situational engagement in traditional learning environment or in online settings (such as MOOCs), the studies of situational engagement applied Csikszentmihalyi' s (1997) flow theory and used the experience sampling method as core methods for data gathering (cf. Linnansaari et al., 2015; Pearce et al., 2005; Schneider et al., 2016).

Learning engagement as a topic has been intensively studied across various learning environments and in a range of subjects (i.e., Brunvand, & Byrd, 2011; Jung & Lee, 2018; Mesquita et al., 2015), but there is little agreement on effective measurements of engagement (Sinatra et al., 2015). The measurement of a learner's engagement varies drastically, depending on the contexts and theories applied in each study. In most cases, engagement as a term was treated as either an outcome or a mediating factor that brings potential benefits to an individual learner, such as a positive learning attitude, or personal wellbeing. Although researchers agree that engagement is a malleable experience that occurs over time, studies to date have paid little attention to how students experience science learning situations (Fredricks & McColskey, 2012). In addition, most early studies also measured engagement by using a once-and-for-all approach, and engagement was generally assessed via a memory-based, after task measurement (for example, Moreira et al. 2018; Pike et al., 2011; Rabe-Hemp et al., 2009). Such an approach is easy yet also problematic, as memory-based tests fail to investigate what happens during a learning task (Ainley & Ainley, 2011). Therefore, measurements of science engagement in real situations, such as using the experience sampling method (ESM) (Csikszentmihalyi & Schneider, 2000; Hektner et al., 2007), could offer new insights on students' engagement in science learning and could reflect more about instructors' abilities in making (online) science more engaging. In addition, not many studies on online learning engagement have used a sample of secondary school students. In most cases, participants were recruited from undergraduates. Therefore, there is a need to understand the situation of students from other levels of education, such as secondary school students. Therefore, in this study, special attention was paid to the secondary school students' situational engagement in a science MOOC, including factors that may be associated with situational engagement, the effect of contexts on situational engagement, and individual similarities and difference.

2.2 Situational engagement

Even though the term *situational engagement* is not something new, existing studies had not paid enough attention to what makes students situationally engaged in science learning (Fredricks & McColskey, 2012). In this study, I rejected the popular idea of conceptualizing engagement as a monolithic trend. Instead, engagement has been treated as context-dependent that could change according to learning environment and situations. In addition, students' engagement in a task is a process that was built in the context of study with various challenging and interesting learning situations. This section started with a summary of studies on (situational) engagement, with a focus on conceptualization and measurement of learning engagement across situations. The relevant theories were introduced. Similar concepts, models, and how they were used in previous works were depicted. This was followed by a section that explained why and how flow theory can be used in this study as a theory of researching engagement across various situations. Several models of flow and approaches to assess situational engagement were discussed, plus an in-depth review of recent studies on situational engagement. Finally, three important pre-conditions of situational engagement including perceived interest, skill, and challenge were proposed based on current work on situational engagement.

2.2.1 Definition for situational engagement

Situational engagement can be defined as students' engagement in certain contexts. And most of the current work on situational engagement was found in the domain of science. For example, Lau and Roeser (2002) defined students' situational engagement in science in the matter of science in a range of settings including school science tests and outside school activities. The study by Schneider et al. (2016) investigated the optimal learning moments in science among Finnish and U.S. students, and they interpreted situational engagement as optimal learning moments under flow theory. The conceptualization of situational engagement in this context was inspired by previous work by Lau and Roeser (2002) and Schneider et al., (2016). Lau and Roeser (2002) proposed situational engagement specially in science based on the assumption that students engaged differently in various situations or settings, such as in a science museum, in a classroom, or during a science test. In a recent study, Schneider and her colleagues investigated the so-called *engagement in-situ* concept and conceptualized it as an optimal learning moment. Situational engagement in their context was built on the idea of "flow" as defined by Csikszentmihalyi (2008), the status when someone is so deeply involved in a task that they lose their sense of time and postpone their basic human needs. However, the situational engagement in this context refers to students' engagement online learning across a range of topics and timeframes.

Schneider et al. (2016) conceptualized situational engagement in the context of flow theory (Csikszentmihalyi, 1990) and proposed three pre-conditions for engagement: interest, skill, and challenge in a task. To be engaged, a student should experience situational interest and challenge in the task and a set of skills in order to undertake the task. In other words, situational engagement was a status that may occur in a given situation/environment, and experiencing it requires interest in the activity, a proper skill set and being aroused by the challenging situation (Schneider et al., 2016). Thus, it is a more emotional and cognitive type of engagement–not so much behavioural.

Situational engagement in this context refers to students' engagement in online learning across a range of topics and timeframes, it was a state that similar to flow as proposed by previous study such as Schneider and colleagues (2016). Thus, situational engagement is related with several contexts or situations of the MOOC, and the level of situational engagement changes across contexts and timelines. In addition, there is a need for tools that collect information from students and measures their engagement in actual learning situations, particularly when attempting to identify when and in what activities student engagement is likely to vary both in time and social and emotional intensity. Therefore, a tool was developed for measuring on-line engagement in this study. It is introduced in more detail in the methods section.

2.2.2 Measurement of situational engagement

In general, the measurement of situational engagement was based on the given definition. Many previous studies addressed situational engagement either from the quality of an individual's emotional, cognitive, and behavioural engagement, or defined situational engagement as a key mediating process of commitment pathway in achievement-based science learning (Lau & Roeser, 2002). Researchers have agreed that engagement is a changeable, malleable experience that occurs over time and varies from situation to situation (Fredricks & McColskey, 2012). In addition, basic assumptions that females are less engaged in science learning are typically based on surveys but not on measurements in real situations.

In practice, measuring situational engagement is challenging, and it is even harder in capturing situational engagement in online learning environments. A major concern is how to operationalize and measure engagement when students are involved in an online science learning activity. If researchers want to measure engagement during science learning, the biggest challenge may be how to obtain engagement data without disrupting the flow of the learning. Due to such challenges, memory-based retrospective questions or observations are used frequently (Sinatra et al., 2015). In most studies, students' engagement and interest are not measured in situations but through surveys or interviews. Surveys and interviews have limitations because they obtain retrospective measures of students' reports on interest or engagement experiences and their subjective feelings or values about them (Ainley & Ainley, 2011; Hampden-Thompson & Bennett, 2013; Tuominen-Soini & Salmela-Aro, 2014). Retrospective approaches have drawbacks because they fail to measure what has happened during the learning process, which can be crucial information for learning analysis. However, there are other options, such as the use of ESM. ESMs have an advantage in measuring situational engagement. They are less likely to disturb the flow of learning, and they allow for a deeper exploration into the contexts as related to what engagement is possible (Csikszentmihalyi et al., 2006). In addition, measurements in real situations through an ESM (Csikszentmihalyi & Schneider, 2000) could provide insights on students' situational engagement during a certain period of time.

The presence of a challenge has been shown to be important to learning engagement and sensitive to situations and environments. With interest (as a precondition of engagement) and skill (as performance capability), in this study I measured secondary school students' engagement across several contexts during a short science course. Although several studies have applied flow theory to the study of online learning, there has been a dearth of research that measure context-specific features of engagement in online settings (i.e., in the domain of science). For instance, the work of Pearce and colleagues (2005) tested students' online physics learning flow in relation to several levels of interactivity. However, this study lacked the proper measurement of engagement in different contexts, which is crucial for understanding students' learning performance and preference. In addition, while Guo and colleagues (2014) undertook a big data-based analysis of learning engagement, they failed to do it in specific situations. Thus, a further study aimed at exploring video engagement and its factors is necessary. In one study by Ainley and Patrick (2006), they used a composite flow scale that included challenge, skill, absorption and control statements, and compared it with the simplified skill-challenge scale based on Csikszentmihalyi's (1990) four channel flow model in an online physic learning task. In such a study, the composite scale was managed at the end of the task while the latter was used several times during the task. This approach of measuring online learning flow is like my conception of engagement in situations. As noted earlier, this study defined engagement-in-situ as task-based or context-dependent in which interest as one of the fundamental properties of motivation is treated as a precondition of engagement. In addition to interest, it draws on the four channels of flow theory, using skills and challenge as another two key preconditions of situational engagement. Situational engagement was thus determined and measured by students' perceived interest, skills and challenge as reported during an activity.

In this study, I extended the idea of Schneider et al. (2016), that they conceptualized optimal learning moments with flow theory and measured engagement in situ through measuring pre-conditions for engagement: interest, skills, and challenge. While they focused on students' situational engagement in and out of school, this study focused on online science learning activity. The approach in this study has an assumption that situational engagement is spontaneous and subtle, and it has three preconditions: perceived interests, perceived skills, and perceived challenge. This study regards situational engagement and interest as varying in intensity across different domains and situations (Krapp & Prenzel, 2011). The decision to use flow theory to depict secondary school students' situational engagement was based on the following considerations: To begin with, flow manifested many features that are of great importance in the online learning environment, such as perceived skills and challenge. Secondly, flow emphasized the frustration and its interaction with other factors during a learning task, which is important, as it eased my understanding of students' engagement in situations and the individual differences associated with that. Finally, as Pearce (2012) noted, flow describes an autotelic experience, which means one who has entered the status of flow is doing something enjoyable for its own sake. To wrap up, flow theory is helpful not only in the understanding of students' engagement in situations but also the proper measurement of online learning engagement. This research was built on previous work (i.e., Pearce, 2012; Schneider et al., 2016) but it was also hoped to extend them from both perspectives of research questions and methods. For example, in terms of methods, a set of questionnaires as developed for measuring online learning situational engagement across various contexts. Ideally, students' situational engagement was constantly monitored and measured throughout the whole learning process. However, this may be challenging because asking a learner to answer several questions during video watching may disturb their learning flow, and consequently have a negative impact on the learning outcome. Nonetheless, in this study I applied six-time pop-up questions that only briefly interrupted students while they were engaged which took them less than one minute to complete. These measurements coincided with the pre-set course situations.

Based on those three preconditions, in this study I claimed that the level of situational engagement may be affected by different contexts/situations of learning. Those above-mentioned factors form the measurable pre-conditions for situational engagement measurement. In addition, an innovate approach was adopted for my study. A series of pop-up questions was created to capture malleable situational engagement, which enabled me to know the ups-and-downs of engagement during a learning task. This is different from traditional ways of measuring engagement at the end of an activity, i.e., memory-based measurement. Specifically, students were engaged when they reported a higher-than-average level of interest, skill and challenge at the same time (i.e., a score of at least three on a five-point scale in all dimensions). A detailed description of all these preconditions has been presented in section 2.2.4.

2.2.3 Connecting flow theory to situational engagement

In domain specific engagement (i.e., science), some researchers conceptualized engagement under flow theory (e.g., Schneider et al., 2016). According to Shernoff et al. (2003, p.160), flow theory is based on “a symbiotic relationship between challenges and skills needed to meet those challenges.” To be engaged, a student should experience a proper level of challenge and have enough skills to cope with the challenge presented. They added interest as one of the preconditions of engagement for it is the psychological predisposition of a specific object (Hidi & Renninger, 2006). Taken together, to be situationally engaged in a science learning task, a student should first, be interested in a relevant topic; second, be equipped with perceived skills that match with the perceived challenge; and finally, to be confident in their capability and perceived skill.

The idea of engagement in a task was depicted in the work of Csikszentmihalyi (2008) when he described the status of an individual so engaged in a task that the sense of time and concept of personal needs vanished temporally. Following the work of Pearce et al. (2005), online learning engagement was treated as an ebb-and-flow process instead of being a once-and-for-all state. Treating flow as a succession of states helps to identify ebbs and flows, up and down trends among learners and several factors that may related to their frustrations. As previous studies have suggested, the meaning of ratio of skills and reported challenge may be different across different points of a task (Ainley et al., 2008). Thus, the understanding of situational engagement contributes to my understanding of students’ online engagement in-depth and in-detail. The definition of situational engagement used for this study is connected with the four-dimensional model of engagement as proposed by Fredricks and colleagues (2004). First, this model emphasized the role of situational interest as a precondition for emotional engagement. Second, challenge and skill as preconditions for engagement emphasized the importance of cognitive engagement (NAS, 2018). Consequently, this definition emphasized emotional and cognitive components of engagement.

According to Csikszentmihalyi (1975), flow is experienced when a balance was struck between the opportunities for action and one's capabilities for it. In a normal situation, one may experience boredom when skills are greater than the opportunities presented, but experience anxiety when it was other way around. Skills in flow theory are related to one's capabilities to handle tasks in activities. Challenge refers to the level of difficulty as an individual perceived during a specific task at hand. According to the four-channel model of flow, flow is supposed to happen when the perceived skills and challenge strike a proper balance. However, when the degree of challenge is much higher than skill, frustration may be experienced, while one may be bored if personal skills outweigh task challenge too much. (Csikszentmihalyi, 1990, p. 72–77). Csikszentmihalyi (1990) also argued that flow can be understood as a status of optimal learning experience of everyday life. The optimal moment may have occurred when the task was sufficiently challenging to require one to exert one's full skill set. Hence optimal learning happens when one has a relatively high skill set and meets with a task that is demanding or challenging.

In addition, earlier studies have shown that the status of flow is more likely to happen when a relatively high challenge and skill are encountered (Shernoff et al., 2014). Across several studies, Csikszentmihalyi and his team managed to draw a picture of what he referred to as optimal experience and its adjacent conditions. The state of flow is characterized by the following components: (a) balance between an individual's skills and challenge and perception of task demand. In other words, feeling capable of dealing with a difficult situation; (b) coherence of activity and clear feedback; (c) inner logic existed in activity; (d) being highly concentrated on the task at hand; (e) a distortion of time, when there seems to be no sense of time passing; (f) the integration of "self' and "task", losing self-consciousness (Csikszentmihalyi, 1975). Some researchers measured flow experience simply by the balance between challenge and skills, instead of applying the nine components scale (Engeser & Rheinberg, 2008). They also investigated the relationship between the perceived importance of an activity, flow experience and skill-challenge balance. The perception of importance mediated the interrelationship between flow experience and skill-challenge balance. Based on these definitions and the literature I can connect situational engagement with flow theory. Readers should be aware that even if I mentioned flow theory here separately, the purpose is to make clear how situational engagement was defined and supported by flow theory. Thus, the theory of flow is used as a theoretical base, and nothing directly related flow will be measured and presented in the later sections, such as results. In the next part, the literature regarding the pre-conditions of situational engagement is firstly summarized (2.2.4) and then several predictors of engagement are presented and related work discussed (2.2.5).

2.2.4 Pre-conditions of situational engagement

Interest as a motivational factor

Interest develops as a result of interaction between individuals and the environment. Interest that is involved in a learning process has the potential to affect what and how individuals learn, and how well they learn (Alexander & Jetton, 1996; Flowerday & Shell, 2015). Learners' interest is an important consideration for educators because they can accommodate those interests as they design curricula and select learning resources (NAS, 2018). As a factor that supports learning, interest has been extensively investigated. In the academic world, the literature on interest and its relationship with learning has focused on three kinds of interest: topic interest, situational interest, and individual interest. Topic interest refers to interest that is elicited by the presentation of a typical topic, and it can be either situational or individual (Trend, 2005). Individual interest is different from situational interest because the former is relatively stable and associated with interest in a typical object/subject, while the latter is more like a state or ongoing process in an interest-driven activity (Krapp & Prenzel, 2011). According to Krapp (2007), differentiating from the perspective that treating (personal) interest as dispositional motivational structure of an individual, situational interest is more about "current engagements" with an activity or in a motivational state of "being interested." Situational interest is malleable, can affect student engagement and learning, and is influenced by the tasks and materials educators use or encourage (Hunsu et al., 2017).

Krapp and colleagues (1992) classified interest as having two main components, namely individual interest, and situational interest. Based on the four-phase interest development model, it starts with triggered interest and maintained interest, which refer to the situational ones that are very dependent on the characteristics of environment. Interest can be triggered for learners of all ages and in all phases of interest, including individuals with little preliminary interest. Interest be triggered by a set of collative variables such as curiosity, oddity, challenge, surprise, entanglement, or uncertainty (Järvelä, & Renninger, 2014). The second phase is maintained situational interest that concerns the psychological state of interest that is followed by a triggered state with which features such as focused attention and persistence over an extended period are involved (Krapp et al., 1992). In this phase, the environment, along with others, tasks, or activities, plays an important role in supporting one's effort to develop a basis for linking to context, and to relate such a context to other available information. Thus, interest in this phase is sustained, and one also starts to develop value for content. According to Linnenbrink-Garcia et al. (2010, p.650), a "…maintained situational interest develops in response to exposure to material in a particular context." That situational interest can be contemporary if the environment fails to support it consistently (Linnenbrink-Garcia et al, 2010). This is the case in online learning: when the normal way for school science to be taught is in the classroom, a MOOC, in both learning environment and course content (in this case 'energy efficiency'), would be a particular context for students. Since my focus in this section is more about interest in situations, there will be no emphasis here on individual interest. Situational interest refers to the affective reaction which can be triggered in the moment by a certain context or subject and normally stay temporarily.

Krapp (2002, 2007) has introduced in the Person-Object-Theory of Interest (POI) as a content-specific motivational variable. Interest emerges from an individual's interaction with his or her environment and depends on content and causes arousal as a function of the 'interestingness' of the event or object just as a school science topic (Hidi & Renninger, 2006; Krapp & Prenzel, 2011). The realization of an interest requires a situation-specific interaction between the person and the object. Object engagement was a term used in describing such interaction including both tangible engagement with an object and the abstract cognitive involvement in a specific task (Krapp, 2007). Schraw and Lehman (2001) describe how situational interest is aroused as a function of the interestingness of the topic and is also changeable and partially under the control of the teacher. According to this description, situational interest is almost the same as topic interest. They also identified three categories of situational interest: content-based, task-based, and knowledge-based situational interest. In addition, this study asserts that the secondary school students' online science learning interest is a task-based situational one; it is spontaneous, fleeting and shared among individuals. In other words, it is more an emotional state than a fixed personal interest; it could be provoked by characteristics of the MOOC such as teaching style, different MOOC context, and may only have a short-term effect on one's attitude, values or knowledge (Renninger & Hidi, 2011). Following the idea of Hidi and Renninger (2006) and Krapp (2007), this study defined students' interest in online science learning as a task-based situational interest. It happens often that when individuals are performing a given task, it can be spontaneous and fragile. Some other studies have found the correlation of perseverance in engagement and positive affect with interesting activities (for example, Ainley et al., 2002; Ainley et al., 2002). A recent investigation of interest reported its mediating role in associated self-regulatory processes. For example, interest has been identified as a mediator of self-efficacy and achievement goal orientations (Hidi & Ainley, 2008). There have also been several studies concerning interest in science. For instance, Hoffmann (2002) found that curriculum change and the classroom environment and its interaction with gender help to increase girls' interest in science and improving their learning results.

Lavonen et al. (2005) extended the concept of interest to science education. They defined interest as it being wrapped with context, task, and (prior) knowledge and skills. Situational interest in a science learning situation, in this sense, could be created by choosing appropriate teaching/learning materials, teaching method or pedagogical activity, like problem-based or inquiry-based learning (Hunsu et al., 2017). For example, doing science experiments, emphasizing social interaction and collaboration, working with models, or choosing appropriate contexts are examples of situational influences for the development of situational interest (Cheung, 2018). Potvin and Hasni (2014) did a systematic review of research on interest, motivation and attitude to K-12 school science and technology, analysing 228 articles that were published between 2000 and 2012 and indexed in the ERIC database. Eight articles examined the influence of problem-based or inquiry-based learning to students' interest in science learning. However, only two of these reported improvement in interest. This is not what was expected because in problem-based or inquiry-based learning, students have choices in formulating questions and in planning of experiments, for example. Linnenbrink-Garcia et al. (2013) have suggested that the perception of having a choice may have a positive influence on interest and engagement.

People measured interest from various perspectives. For example, some measured interest based on positive feelings, value and stored knowledge, and repeated engagement (Hidi, & Renninger 2006; Renninger et al., 2002). Others identified interest simply in terms of liking (Koeller et al., 2001; Wigfield et al., 1997). Most measured interest, especially in science, used knowledge, effect and value as components of interest (Ainley & Ainley, 2011) or more specifically, in terms of content topic, activity type, and learning goal (Swarat et al., 2012). Interest as a basic motivational factor was applied as a prerequisite for the optimal learning moment in a previous study (i.e., Schneider et al., 2016). Hence, the measure of on-task interest is crucial for understanding flow and situational engagement better, in this context. Situational interest is the one that is caused mainly by external factors (Hidi, 1990; Schraw et al., 2001). It is defined as a short-lived interest that arises impulsively because of either features of environment or simply an engaging text. It may influence knowledge, value to some degree, but not on a long-lasting basis. A previous study found that situational interest can be strengthened via modifying the learning environment or changing the context of study, such as teaching strategies and task presentation (Chen et al., 2001; Durik & Harackiewicz, 2007). In addition, situational interest has been shown to predict learning engagement; for example, physical education (Chen et al., 2002). In science activities, students may report an increased interest and higher level of (positive) attitude to science when engaged in group work such as investigating (Tytler & Osborne, 2012). Such enhanced interest and attitude turn out to promote emotional engagement.

Building on previous work (i.e., Ainley, 2012; Hidi & Renninger, 2006) in this study I argued that in the context of online learning, students may hold situational or topic interest, and such interest could be influenced or inspired by external factors such as interesting teachers or interesting topics/content. At the base, interest is a crucial psychological factor for guiding and energizing students' engagement within and outside school activities. This engagement can be very context specific, that is situational engagement. But a "working" (situational) interest can either be caused by existing individual interest or by the special conditions of teaching or learning or a work situation (interestingness). In addition, the role of context is emphasized as the starting point for the development of situational interest (Bennett et al., 2004). The contexts, with the effect on situational interest, further contribute to engagement in situations. In addition, students' interest in online science learning is content-specific situational interest, in which they may only engage in a few sets of specific content areas (Renninger et al., 2002). Another justification of how interest is defined, as Hidi and Renninger (2006, p.112) put it is, "Each phase of interest is characterized by varying amounts of affect, knowledge, and value." Hence, in this study it is argued that interest is a property that cannot change too much in a 45-minute MOOC. Students' interests in a MOOC are mostly situational (being a triggered interest or a maintained one), and the development of interest depends not only on the person but also on the environment and content (Hidi & Renninger, 2006).

The need of skills in a task

The second precondition of situational engagement in my context is skill, which refers to one's knowledge and capabilities in a specific domain. Students' skill is defined as a task- or domain-specific mastery needed to complete a task (Brophy, 2008). When students feel skilled, they believe that they can master the ongoing task, which keeps them working towards a goal. However, a high level of skill does not directly lead to situational engagement, as the self-evaluation of skill is related to the difficulty or challenge of the task. Skills was defined according to the domain competence as described by Le Deist and Winterton (2005), but in the context of this study, it refers only to students' science knowledge. Skills and challenges are regarded as the two crucial properties in flow theory (Csikszentmihalyi, 1975).

To conceptualize skills, some previous definitions of skills and competence were referred to. For instance, Cockerill (1989) defined skills as including output competence (such as presentation skills) and inputs (i.e., self-confidence), while Dooley et al. (2004, p.317) defined skills as the "performance capabilities needed to demonstrate knowledge, skill and ability (competency) acquisition." In addition, others conceptualized skills from a certifiable knowledge, skills and attitude (KSA) view (Jeris & Johnson, 2004). In academic research, the term competence is regarded as being both a similar and a broader concept of skills. This can easily be explained by the definition of competence. For example, domain competence is described as both one's willingness and capability, which is based on domain-specific knowledge and skills, to perform a task (Le Deist & Winterton, 2005). Going back to 1950, White defined competence as "a basic motive for the acquisition of knowledge, mastery of skills, need for exploration" (Mulder et al., 2009, p.756). There are also two reverse perspectives in defining skills, the positivist and the negativist. For example, the positivist pertains that skills can be a property measured quantitatively, and they can be assessed through tests on verbal or other attributes. This study stands in line with the positivists, and skills in this study refers to students' perceived knowledge and capabilities in copying with challenges as presented in different situations in online science study.In addition, in this study, I approached skill using quantitative measures to know how students change their level of perceived skill in response to a course challenge that varies according to contexts.

The presence of challenge

In addition to interest and skills, the presence of challenge is also important for situational engagement. To investigate the flow phenomena in an online environment, it is important to conceptualize the perceived challenge properly (Chen et al., 2000). According to Csikszentmihalyi (1990), challenge is of great importance from the perspective of optimal learning experience (in this case, situational engagement), as optimal experience moments occur when one feels a deep sense of enjoyment and performs a task that is demanding but also challenging. Challenge is defined as a desire to persist in a science-learning situation (Eccles & Wigfield, 2002). Therefore, challenge is seen as a positive state in which students use their skills to meet the demands of the task. In a given situation, an individual may be aware of any potential chances that are challenging them, meanwhile they assert their capabilities in order to cope with the present challenges. This balance between one's perceived skill and challenge is the core idea of flow theory (Csikszentmihalyi, 1975, p. 50). In the field of education, when the learning situation exceeds students' skills and the task or content is too demanding, students are likely to become disengaged. Furthermore, a student must also experience situational interest in the task, as outlined above. Situational interest is defined as a psychological predisposition for a specific object. As a summary, a student is considered to be engaged in a task when he or she simultaneously experiences elevated feelings of challenge, skill, and interest.

Challenge refers to one's desire to persist with a difficult course of action (Salamone & Correa, 2002). The focus in this study is more on academic challenge, and it refers to the feeling of pressure in the presence of the academic task in question, thus the individual's perceived level of challenge may vary in accordance with the contexts. Previous studies have found that a vague definition of challenge may be problematic. For example, in an earlier study, Chen et al. (1999) used the term 'positive challenge' and many students reported that they were confused by this term, which affected the quality of their data collection. Several years later, university students involved in Pearce's (2004) research also reported confusion over the concept of 'challenge' in a questionnaire. Mentioning why the term 'challenge' is hard to ask about in a questionnaire, Ainley et al. (2008) believe that it is partly because 'challenge' is so complicated and multifaceted: it is negatively associated with saying something is 'difficult' or that being difficult is beyond thinking but can still be cognitively stimulating. An alternative way to see the term 'challenge' is in the context of the *Adventure Experience Paradigm* (AEP) developed by Martin and Priest (1986). AEP is a similar model of optimal experience through which the challenge-skill measures of the flow model were modified slightly, using a balance of perceived risk and competence to assess a state of *peak adventure*, which Martin and Priest believed to be like the flow state. How challenge was measured is described in Chapter 4 (methods).

In addition, challenge is crucial to student engagement and achievement (Fredricks et al., 2002; Lutz et al., 2006; Planty et al., 2009). And recent studies on student disengagement also shed light on using challenge as a possible remedy for disengagement (Shernoff et al., 2003; Yazzie-Mintz, 2010). In science learning, students' perceived challenges were positively associated with their reported level of engagement, and instrumental support from teacher was positively related with engagement across all challenge levels. Students' perception of the task at hand requires a sorting of cognitive and physical investment (Csikszentmihalyi, 1990; Shumow & Schmidt, 2014). The feelings or experience of a challenge is subjective, which means the perceived challenge can either depend to a larger extent or mainly on self-evaluated personal skill. The perceived challenge is something that varies in different situations. For example, in certain contexts, students may be motivated by the presence of a challenge, while being discouraged in some other situations (Csikszentmihalyi, 1990; Schmidt et al., 2010).

In the next section, previous studies on factors of engagement are reviewed, placing special emphasis on studies that focus on concepts such as self-efficacy, attitude (or feeling-related interest; value-related interest), and individual similarities and differences (sections 2.3 & 2.4). In addition to that, a summary of online learning individual difference was conducted (section 2.5). Based on the literature review, the conceptual framework of this study was presented accordingly.

2.3 Predictors of (situational) engagement

In this section, several assumed predictors of situational engagement, including self-efficacy, feeling and value-related interest, were reviewed. Hypotheses were also formulated based on the literature review. Thus, the whole section follows a literature review-hypotheses process.

2.3.1 Self-efficacy and learning engagement

The effect of self-efficacy on learning engagement has been depicted in the literature for a long time. For example, self-efficacy was a crucial component of social cognitive theory (see Bandura,1977; Bandura, 2006b). Self-efficacy was first described in early work by Bandura (1977a, 1997). He maintains that an individual's beliefs about their abilities and the expectations they hold can influence their behaviour and described perceived self-efficacy as people's self-evaluation of abilities to arrange, execute and keep behaviour/action to achieve typical goals. According to social cognitive theory (Bandura, 1986), self-efficacy beliefs determine people's choices, the effort they invest, and how long they persist in the face of difficulties. In addition, it also determines the degree of anxiety they experience in various daily tasks during their long lifetime. Though educators have long agreed on the important role of students' perceived conception of academic skills in their motivation to achieve, they have also agreed that students' self-efficacy about academic performance was "hard to measure" (Zimmerman, 2000). Earlier studies (i.e., Bandura, 1977b) also managed to measure self-efficacy from different dimensions (e.g., level, generality and strength) across various environments and subjects. Among them, the level of self-efficacy refers to a task's difficulty level as it depended on the generality of self-efficacy related to transferability, which means one's ability to transfer self-efficacy beliefs across various context. For example, from the context of geography to nature science. However, the strength of self-efficacy deals with one's assurance (i.e., level of confidence) in the task in question. In practice, those dimensions are measured with questionnaires in a range of activities and contexts.

Many studies were conducted by following the proposed self-efficacy theory and it was tested in a range of situations and fields. One such aspect is academic self-efficacy. For example, Pajares (1996) summarized the self-efficacy beliefs and associated factors in the academic world and emphasized the functionality of self-beliefs such as self-efficacy in students' academic achievement and performance. Domain-specific self-efficacy, including its constructs and source, have been tested and applied consistently since then. For instance, in science (see Britner & Pajares, 2006; Lent et al.,1991); reading and writing (Schunk, 2003; Shell et al.,1989); computer and technology (see Compeau & Higgins, 1995; Thatcher & Perrewe, 2002); and recently extended to online learning (see Bates & Khasawneh, 2007; Shen et al., 2013). It has been proven that online learning self-efficacy is associated with self-regulation, learning satisfaction and learning performance (Wang et al., 2013). In the domain of science, students' self-efficacy as a concept was defined as a student's perception of ability to apply knowledge and skills when challenged by new science-based tasks (Uitto, 2014). Four sources acted in an additive way to build science self-efficacy, including mastery experience, vicarious experience, social persuasion, and physiological (psychological) state with mastery experience as the leading source (Chen & Usher, 2013).

Several similar concepts are related to self-efficacy. Such related concepts have been illustrated and compared in early work by Schunk (1991), and later in work by Pajares (1996), including perceived control, expectation and value, and self-concept. Perceived control which consists of means-ends beliefs (the extent that causes lead to certain results/outcomes), capacity beliefs (if one has or can acquire the potential causes), and control beliefs (if one can produce the outcome without reference to any specific means). Another similar concept is self-evaluation. Bandura (1986) regards self-evaluation as human capability and defined self-efficacy, one of the most important aspects of self-evaluation, as beliefs in one's capabilities to organize and execute the course of action required to manage prospective situations. According to Bandura (1991), self-efficacy influences one's activity choice, preparation, effort exerted during a task, thinking patterns, as well as emotional reactions. Among those constructs, self-efficacy was reported as being similar to capacity beliefs, and sometimes the term 'self-efficacy expectations' and 'capacity beliefs' were used interchangeably (see: Schwarzer, 2014). Even though perceived control is important for students, students with perceived control will not possibly will be more motivated and have the desire for learning (d'Ailly, 2003). Self-efficacy is also tightly connected to expectancies. There are two types of expectancies that affect behaviour, being outcome expectancies (one's belief that certain behaviour will lead to certain outcomes) and self-efficacy expectancies (beliefs in their capabilities to produce given attainments). Expectations of self-efficacy are the most compelling determinants of people's behavioural changes, as it directs the initial decision to exert efforts in performing a task, and to persistence, in a challenging situation or a behaviour in question. Zimmerman further developed the theory of self-efficacy and he introduced its role in academic motivation and learning, especially regarding students' ability to regulate their learning activities. The questionnaire fits with Bandura's (2006b) definition from the expectation perspective. The aim of this study was to measure students' online science learning self-efficacy, and this was measured before the course began, so was more an outcome-based expectation than self-efficacy beliefs and changes in situations (Zimmerman, 2000).

Expectation and values theory argue that human behaviour is the joint effort of (a) an outcome as expected from a certain action, and (b) the degree to which individuals value the outcome (Eccles, 1983; Meece et al., 2006). In other words, both the outcome-based expectation and the perceived value must be satisfied to initial an action. As Schunk (1991) put, "An attractive goal, along with the belief it is attainable, motivates people to act" (Schunk, 1991, p.211). Self-efficacy theory is differentiated from expectations-values in its emphasis both on students' beliefs of competence to learn and the motivations involved to use skills and knowledge. For instance, a child who values receiving candy from his or her mother and believes that being able to read the alphabet will get the candy from the mother will not necessarily be motivated and persistent in doing so, as he/she may lack the confidence to pursue that goal.

Self-concept is among the most compared term in academic discussions about self-efficacy. Self-concept was defined as collective self-perceptions that are based on one's interaction with the environment, and heavily influenced by reinforcements and evaluations (Trautwein et al., 2006; Shavelson & Bolus, 1982, March). Other constructs such as self-esteem (perceived sense of one's self-worth, if someone accepts or respects oneself), and self-confidence (an individual's belief of his/her competence in preforming a task or achieving a goal) were also tested and compared with self-efficacy (see: Lane et al., 2004; Zulkosky, 2009, April). Regardless of the similarities and differences that exists in these concepts, self-confidence seems to be close to self-efficacy. However, for the purpose of this study, the concept of self-efficacy was chosen instead of others such as self-concept and perceived control. Why? There are two justifications. First, self-efficacy is generally constructed to be domain specific, and it is more like a lower level of self-concept (Schunk, 1991). Self-efficacy measures render more predictive advantages than self-concept, which suits specific subjects, such as in science and mathematics (Britner & Pajares, 2006; Chen & Usher, 2013; Parker et al., 2014). Second, in academia, an individual who reports a high level of self-concept does not necessary imply that they have a high level of confidence doing all academic jobs (Schunk, 1991).

Schunk (1989b) has described the mechanism of self-efficacy in academic learning settings. In the first phase, self-efficacy varies as a function of aptitude and prior experience. Students hold different beliefs regarding their abilities to acquire knowledge or execute a task. Two sets of factors affect their academic work: Personal factors (e.g., goal setting, information processing) and situational factors (i.e., feedback and rewards). These factors act as signals for students' evaluation of their own efficacy. They become more motivated as they perceived that processes have been made or more skilful in performing tasks. That explains the basics of how self-efficacy operated. According to Zulkosky (2009), there are multiple ways that cause people to have a sense of self-efficacy, either to perform a task successfully or to watch others complete a task successfully or receive positive feedback on finishing a task or from physiologic signals. Schunk and Pajares (2005) found that students with higher self-efficacy tend to exert themselves, evaluate their progress more frequently and apply more self-regulatory strategies, which in turn leads to future success at school. In a literature review, Usher and Pajares (2008) proposed an important idea by stating that researchers and the public alike should work jointly in understanding the role teachers, peers and guardians play in creating and developing students' academic confidence, thus cultivating their self-efficacy.

In practice, the measurement self-efficacy was usually conducted before students undertook tasks or activities, which means that it focuses more on one's prediction of future functioning. Early work by Bandura (1977b) measured self-efficacy from several dimensions (level, generality and strength) across various environments and subjects. But there is criticism. For example, Zimmerman (2000) postulates that instead of measuring personal quality, measurement of self-efficacy should focus more on students' performance (Zimmerman 2000). Early studies proved that self-efficacy is an important predictor of engagement, in addition to self-efficacy, which is how students' view of a certain subject affects their learning engagement (Caraway et al., 2003; Linnenbrink & Pintrich, 2003; Walker et al., 2006). For example, self-efficacy has been found to be correlated with students' perceived intrinsic interest in a writing revision tasks and in a motoric learning task (Zimmerman & Kitsantas,1997; Zimmerman & Kitsantas,1999). In addition, self-efficacy beliefs were found to be sensitive to changes in students' performance circumstances, mediated academic achievement, and to interact with a self-regulated learning process (Zimmerman, 2000). Previous studies have proved self-efficacy's role in predicting students' future major and career preference (Brown & Lent, 2006), and it also predicts students' academic achievements in various subjects and activities (Pajares & Urdan, 2006).

The relationship between self-efficacy and engagement in an online learning environment was also explored. For example, the study by Prior et al. (2016) tested the interrelationships between attitude, digital literacy, self-efficacy, and effect of self-efficacy on peer engagement and course convener interaction. Structural equation modelling (SEM) based on several hypotheses revealed that attitude positively contributed to self-efficacy. In addition, self-efficacy positively affected peer engagement and convener interaction. This finding is significant as it proves that students with higher self-efficacy are more likely to interact with their peers. This kind of interaction in turn prompts discussion in an online learning environment. Thus, a student's positive attitude should be well-supported as it contributes to their self-efficacy in online learning.

In the fields of STEM education, it has been found that affective factors such as self-concept of mathematics being the strongest predictor that explaining variation in Finnish students' mathematics performance (Välijärvi, 2007). Also, in Finland, according to a meta-analysis of PISA data on science, self-efficacy and other factors were found to be effective student-level predictors of science achievement. These factors include science related self-concept and interest, and usefulness of science (Lavonen & Laaksonen, 2009). In an online learning environment, work has already been done in terms of examining interrelationships between self-efficacy, self-regulation, self-esteem and their predictive role in learning engagement (for example, Bresó et al., 2011; Ouweneel et al., 2013; Shea & Bidjerano, 2010). In this study, the aim was to replicate previous findings on self-efficacy and its effect on learning engagement, but with a slightly different perspective, as it also focuses on situational engagement in online learning.

Thus, the first hypothesis based on the literature review is:

H1a. *Secondary school students' self-efficacy about science is a positive predictor of online science learning situational engagement.*

2.3.2 Personal interest in science (feeling & value-related valences)

In this study, question items from the PISA science attitude questionnaire were adapted. Two dimensions, namely enjoyment of science and value of science, were interpreted as feeling-related interest and value-related valences of interest, separately, based on Schiefele's (1991) classification of personal interest, and the previous definitions of science attitude (e.g., Osborne et al., 2003). Considering these reasons, this section is based first on a review of the literature on science attitude, then a summary of the constructs and literature regarding personal interest in a way to combine both concepts. This order will better explain how pupil's feeling-related and value-related science interest were measured for this study.

Be it positive or negative, students have an attitude about most disciplines and topics (Maio & Haddock, 2010). For example, in science education, attitude as a term is used in a range of contexts. In general, science attitude was classified as having two distinguishing sub-variables, namely attitude toward science, and scientific attitude (Gardner, 1975). Attitude toward science consisted of factors such as attitude to scientists, interest in science, usefulness and the social responsibility of science. It refers to one's feelings, values, or beliefs on a science-related object (i.e., undertaking scientific activities, doing school science, the social effect of science). Scientific attitude is more about how individuals look at science as a domain or subject, or one's scientific spirit (e.g., cynicism, unbiased, integrity). Scientific attitude is a complex mixture of the desire to know, to understand, to question, and to search for the scientific data, meaning, or for verification (Osborne et al., 2003). Such attitudes are normally associated with certain scientific acts or thoughts, which reflect one's ability to response to a situation constantly, rationally and objectively.

Table 2-1. Dimensions and item examples of PISA 2006 science attitude (Feeling-related interest &Value-related interest, as used in this study) measurement

Themes	Dimensions	Items examples
Q16 enjoyment of science (variable in PISA) **Feeling-related interest (variable in this study)**	Indicate curiosity in science and science-related issues and endeavours. Demonstrate willingness to acquire additional scientific knowledge and skills, using a variety of resources and methods. Demonstrate willingness to seek information and have an ongoing interest in science, including consideration of science related careers.	How much do you agree with the statements below? (4 scale from:" strongly *agree" to "strongly disagree*") 1. I generally have fun when I am learning natural science topics. 2. I am happy doing natural science problems 3. I am interested in learning about natural science.
Q18 Responsibility towards resources and environments (variable in PISA) **Value-related interest (variable in this study)**	Show a sense of personal responsibility for maintaining a sustainable environment. Demonstrate awareness of the environmental consequences of individual actions. Demonstrate willingness to take action to maintain natural resources.	How much do you agree with the statements below? (4 scale from: "*strongly agree*" to "*strongly disagree*") 1. Advances in natural science and technology usually improve people's living conditions. 2. Some concepts in natural science help me see how I relate to other people. 3. Advances in natural science and technology usually bring social benefits.

Some studies defined the constructs of attitude in science. For example, in a questionnaire measuring attitude, five dimensions of attitudes were included, that is, learning science at school; practical work in science; outside school science; the importance of and self-concept in science; and future participation in science (Barmby et al., 2008, p. 1077). PISA 2015 defined attitude to science according to three aspects: interests in science and technology, environmental awareness and valuing scientific approaches to enquiry (OECD, 2017). This study conceptualized the idea of interest in science from previous studies on science attitude, such as the PISA 2006 student questionnaire (OECD, 2005). In academic research, attitudes toward and interest in science were sometimes used interchangeably. Attitudes toward science, according to Osborne and colleagues (2003), is "the feelings, beliefs and values held about an object that might be the enterprise of science, school science, the impact of science on society or scientists themselves" (Osborne et al., 2003, p.1053). This definition, corresponded to Schiefele's (1991) classification of personal interest as having two valences, namely feelings-related interest and value-related interest. To that end, science attitude in this study was focused more on the feelings and value-related aspects, which are similar to perceived enjoyment of science, and its value for oneself and for society. Enjoyment and the value of science were interpreted as feeling-related and value-related interest based on theories of interest and motivation as proposed by experts such as (Schiefele, 1991).

In this dissertation, students' attitude toward science was mainly treated as personal interest that included both feeling-related valences and value-related valences. Table 2-1 demonstrates attitudes toward the science section of the PISA 2006 student questionnaire. For this study, only Q16 and Q18 were adopted, representing *feeling-related interest* to science and *value-related interest in science*, separately.

According to Bybee and McCrae (2011), in the PISA 2006 test, the student questionnaire regarding science attitude was divided into three parts, namely enjoyment of science; support for science enquiry; and responsibility towards the environment. According to Table 2.1, when explaining the dimensions of 'enjoyment of science', different key words were used, including 'curiosity', 'willingness' and '...ongoing interest'. It is arguable that such enjoyment can be interpreted as feeling-related interest in science. Among the evidence from Schiefele (1991), in his classic definition of individual interest, he argues that personal interest has two valences, being feeling-related, and value-related valences respectively The former refers to the feelings that are related to topics or objects, whilst value-related valences refer to 'attribution of personal significance to an object'. Both of those types of interest were intrinsic. The feeling-related component of interest is more about the feelings of excitement that caused an object or activity to arise, while the value-related component refers to things that may bring personal meanings to many people.

Some researchers have assessed students' feeling-related interest and value-related interest in the domain of science. In a study that analysed Finnish students' science performance of PISA test, Lavonen and Laaksonen (2009) applied the concept of *attitude* from PISA 2006 framework, but attention was paid mainly to feeling-related interest (Q16) and the value of (or responsibility toward) science (Q18). However, this ignored items relating the *support for science enquiry* (Q17) data analysis. In this study I adopted several items from Q16 and Q18, renamed the five items from Q16 as *enjoyment*, and the four items from Q18 as "*personal value*". For example, the questions in Q18 deal with individuals' responsibility towards the environment, but also emphasized how people judge the importance of science, either at a personal level or in a boarder social context. Issues related to reliability and validity are reported in the next chapter. In environmental science, earlier studies have found that students with a stronger interest in environmental issues tend to have a more positive attitude to responsibility, and likewise, a higher positive attitude about the environment was also associated with stronger biocentric values (Uitto et al., 2011).

Lastly, it is worth mentioning that the concept of science attitude and science interest were sometimes used interchangeably. Although some authors suggested using both concepts synonymously (Schreiner, 2006; Schreiner & Sjøberg, 2004), others (i.e., Osborne et al., 2003) insisted that the concept of attitude was superior to that of interest, so they treated interest as a specific form of attitude that was characterized by a certain object area (Krapp & Prenzel, 2011). One of the differences is that attitude involves an evaluation process, while subjective value or feelings that are attached stand out as being more crucial for interest. A person can therefore be interested in one activity or object while holding a negative attitude towards it. Research efforts made by STEM educators have shaped our understanding of science interest and attitude. Attitude and interest are formed by both personal and environmental characteristics. Some effort has been made to distinguish students' general attitude to science and attitude to school science (Shirley, 2014). For example, 15-year olds may find science to be interesting, useful and might hold a positive attitude, but this does not necessarily mean that they have a positive attitude to school science. To be clear, this study focused more on general perspectives of science rather than school science. Attention was paid to teenagers' situational engagement in a short online science MOOC, and science attitude was based on two aspects: Feeling-related personal interest and value-related personal interest in science.

Based on the literature review, this study assumes the following:

- H1b. *Secondary school students' value-related interest in science is a positive predictor of online science learning situational engagement.*
- H1c. *Secondary school students' feeling-related interest in science is a positive predictor of online science learning situational engagement.*

2.3.3 Situational engagement and science achievement

The topic of achievement and engagement has been a classic one in educational settings. Students' achievement in most studies was based on subject grades or knowledge tests (Singh et al., 2002). For example, in the domain of science, achievement was measured by a set of knowledge tests, such as in the Trends of International Mathematics and Science Study (TIMSS, 2003); In PISA tests, 15-year-old students' know-what (scientific knowledge), know-how (i.e. to apply scientific knowledge to solve real-life problems), know-why (e.g., to explain scientific phenomenon) was one of the four important dimensions of scientific literacy (Bybee & McCrae, 2011). PISA assessments of scientific literacy are based on questions set in context-rich scenarios, and the term *literacy* reflects the OECD's emphasis on understanding and applying science-related knowledge in real-life situations (Ainley & Ainley, 2011). Sometimes science knowledge (as related to achievement) is accessed using several question items both before and after interventions (Djonko-Moore et al., 2018).

There is proof that engagement and achievement are positively correlated (Chang et al., 2007; Ogan-Bekiroglu & Eskin, 2012). In most cases, engaged individuals perform better than their disengaged counterparts. In educational research, it has been found that the use of technology in class (i.e., mobile devices, audience response systems) has a positive effect on learners' engagement level, which in turn, promotes students' achievement (Rashid & Asghar, 2016). Higher levels of engagement that are associated with appropriate cognitive processes promote continuing motivation, commitment and general task performance (Shernoff & Hoogstra, 2001). Environment also played a role in developing better engagement and improving learning performance, as the richness of a learning environment may lead to better task performance (Ahlfeldt et al., 2005). Engagement mediates the influence of curricular and instructional changes on student performance and achievements (Blasco-Arcas et al., 2013). Kahraman's (2014) study found different patterns of relations between science engagement and achievement in 4^{th} and 8^{th} grade students. In 4^{th} graders, liking science has a positive influence on science achievement, whilst 8^{th} graders' emotional engagement was also positively related to their science achievement.

However, there are few exceptions. Rashid and Asghar (2016) examined the complex interrelationships between technology use, self-directed learning, student engagement, and their achievement by college students. The results suggested that technology use has a direct positive effect on learning engagement, but no clear link was found between learning engagement and students' learning achievement. Based on the literature review, for this study it was assumed that in a MOOC learning environment, students who are situationally engaged will be more likely to perform better in post-knowledge tests.

2.4 Contexts of learning and situational engagement

According to the literature, previous studies that focused on video and learning engagement were mainly on video (content) engagement (i.e., Dobrian et al., 2011; Guo et al., 2014, March; Shafiq et al., 2014, June; Sherer & Shea, 2011), or on video game engagement (i.e., Przybylski et al., 2010; Skoric et al., 2009). Research on both aspects started to become popular from 2009-2010, with several highly-cited articles emerging. For example, Skoric and colleagues (2009) assessed the relationship between elementary school students' video game engagement and school performance to investigate how video game addiction related to school performance.

Their findings indicated a negative tendency between game addiction and school performance. Another study by Przybylski, Rigby and Ryan (2010) tested and then formed a motivational model based on self-determination theory, which examined and evaluated how video games shape dispositional process and are associated with wellbeing. Hence, this model was used, and it has motivated many researchers in the relevant field.

There are also other contextual factors affecting students' learning motivation and engagement, such as autonomy. Autonomy refers to the need to act on one's own with choice and self-determination. It is regarded as one of the basic psychological needs (Deci & Ryan, 2000). Earlier studies have found that autonomy influences students' behavioural and cognitive engagement, as autonomy directs one's actions, as well as determining and evaluating their goals and decisions (Lee et al., 2015). Autonomy is also a crucial component of motivation in self-regulated, online learning environments (Chen & Jang, 2010). With the presence of autonomy, students are more likely to engage actively and feel a stronger sense of ownership and responsibility for the work. Lee and colleagues (2015) provided three guidelines that can be used to support student autonomy: providing choices; providing rationale (i.e., explicitly stating the motivation and rationale for course assignments); and connecting personal values to course objectives (e.g., what does the course assignment mean to you and your culture?) (Lee et al., 2015). In authentic online learning, it is important to provide choices for students to support students' self-regulated learning.

Teachers or teaching styles also played a role in students' engagement in some situations. For instance, a previous study on video engagement found that videos with teachers speaking at a fairly fast speed are more engaging compared with those in which teachers are speaking slower. In addition, videos that intersperse an instructor's talking head with slides are more engaging than slides alone (see Guo et al., 2014). Another frequently discussed topic is teaching presence, one important constituent of community of inquiry theory (Garrison et al., 2010). Teaching presence was defined as "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" (Anderson et al., 2001, p.9). Teaching presence in an online learning environment was seen "as a significant determinant of student satisfaction, perceived learning, and sense of community" (Garrison & Arbaugh, 2007, p. 163).

Situational engagement has been found to be unstable and context dependent. In general, students' level of engagement in situations changes in accordance with course arrangement and features of activities, such as in aspects of cognitive engagement. Rotgans and colleagues (2018) were interested in how college students' cognitive engagement fluctuated during a team-based learning (TBL) session. Using an ESM approach, they were able to measure students' cognitive engagement across the whole learning session. The results showed that students' self-reported level of cognitive engagement fluctuated significantly in all six measurement points, and TBL session were more engaging than non-TBL sessions. A decade ago, Pearce et al. (2005) had already explored the ebb and flow of online learning in science domains. They conducted an experiment in which students worked through a learning sequence that had different levels of interactivity. Significant differences were found across the learning tasks, thus supporting the argument that flow (in this case engagement) is better understood as a process, instead of as a stable status. One of the hypotheses (H2a) of this study has an assumption that secondary school students' situational engagement in a science task is a process that with ups and downs, depending on the context of the course (knowledge). Thus, these earlier studies provide sufficient theoretical ground for study engagement in different situations.

In science learning, studies on situational engagement were mainly conducted at school and in out-of-school environments. The context of task has been found to affect students' level of engagement. For example, the study by Inkinen et al. (2018) investigated students' situational engagement in secondary school science classroom activities among pupils in the U.S. and Finland. Situational engagement was conceptualized as times when one perceives a task as interesting and challenging when having the competence to cope with the challenge. Finnish students were situationally engaged more when calculating and presenting scientific information, while the U.S. students reported more engagement in situations such as discussing scientific information (Inkinen et al., 2018). Another recent study on science situational engagement was conducted to examine high school students' situational engagement across different classroom activities in America and Finland (Inkinen et al., 2020). A higher level of situational engagement was found between both American and Finnish students during activities such as developing models and constructing explanations. Finnish students also reported a higher level of situational engagement when using a model.

Inspired by current studies on science situational engagement, this study tried to extend such situational engagement in online learning settings. For the purpose of this study, three specific contexts/situations were set, namely *contextualizing, explaining a concept/model, and making a summary*. The purpose is to understand whether and how different contexts will affect students' reported level of situational engagement. The criteria and procedure of selecting contexts is depicted in section 3.2. Based on the literature and the research design in this study, it is assumed that in secondary school students' online science learning:

- H2a *Secondary school students' level of situ-engagement differed by various contexts of course knowledge.*
- H2b *Secondary school students engaged more with online MOOC videos that the teacher was contextualizing (i.e., statistics of energy consumption in Finland), compared with other situations (making a summary & explaining a concept).*

2.5 Individual differences of online learning engagement

2.5.1 Gender similarities and differences (in related to SE, attitude, achievement, and engagement)

Girls and women are underrepresented in STEM-related fields (Burke & Mattis, 2007;

Cheryan et al., 2017; Stoet & Geary, 2018). The difference in engagement and learning in both genders, especially for online learners, needed to be researched, as students' gender is a significant factor that contributes to science engagement (Osborne et al., 2003). Globally, boys have a weak superiority over girls on aspects such as positive attitude, motivations towards science, and science achievement (Sorge, 2007). Meanwhile, boys participated more in science-related activities, and tended to have a higher degree of self-efficacy when compared with girls (OECD, 2016). Girls are also less likely to pursue careers in science, but this gap is decreasing, especially in the life sciences (OECD, 2006). In American elementary and middle schools, significant differences were found between male and female students on motivation, enjoyment and anxiety. In general, females reported more learning anxiety, but they were less motivated and regarded science as less fun when compared with males (Desy et al., 2011). However, no significant differences were found between boys and girls on values of science in society and interest in science across all grades.

Findings on gender differences in science subjects are not always consistent. For example, some science education researchers claimed that girls and boys are both positive about science at the elementary school level (Vanmali & Abell, 2009), but girls at elementary level tend to perceive their science abilities differently from boys. Similarly, at secondary school, boys reported a higher level of science self-efficacy than girls in two out of three countries, expressed a stronger science interest than their female counterparts, and generally reported more enjoyment than girls in learning science (Miller et al., 2006; Stoet & Geary, 2018). In Hong Kong, male secondary school students demonstrated a significantly higher degree of positive attitudes towards science in all the dimensions studied, such as self-concept in science, enjoyment in science, learning science in and outside the classroom, and future science participation (Wan & Lee, 2017). Meanwhile, girls received less attention in science classrooms than their counterparts (Greenfield,1997), and they also reported science as being difficult more frequently (Jones et al., 2000). In addition, many researchers argued that in general, girls are less interested than boys in physics, and that student interest in physics decreases as student age increases (Collins et al., 2000; Tytler et al., 2008). In addition, female students also engaged actively in science activities; initiated as many teacher interactions as did boys (Greenfield,1997); and liked the people-oriented science subjects. Christidou's (2011) study was focused more on students' view of science and being a scientist as an occupation. He found that fewer boys than girls see science as "competitive, impersonal, abstract, rule-founded, certainty-bounded, deprived of imagination and as a product of individual effort made exclusively by male scientists" (Christidou, 2011, p. 144). As in most studies, boys generally are more interested in science than girls. In addition, Häussler and Hoffman (2002) found that upper secondary school girls displayed significantly more interest in the physics related to the working of a pump when the mechanism was put into a real-world context: the use of a pump in heart surgery.

In Finland, students' interest and motivation in science learning has been investigated using the international Relevance of Science Education (ROSE) survey framework. Finnish female students were found to have more interest in topics that are associated with human beings, such as human biology and health education, whilst boys were more interested in science topics with technology contexts (Lavonen et al., 2005; Uitto et al., 2004). In terms of attitude and the value of science, a study on Finnish students has identified several gender differences. For example, girls tend to hold a higher attitude about environmental responsibility than boys (Uitto et al., 2004). However, in a recent study on students' optimal learning moments, factors such as active feelings and happiness were reported to be higher in males than in females. Meanwhile, females reported a greater level of stress in science classes compared with males (Schneider et al., 2016). In general, on a topic such as environmental issues, girls' attitude was also significantly more positive and their biocentric value stronger than those of the boys (Uitto et al., 2011). However, Finnish boys and girls have a small difference in science interest. Several studies have explored how the level of situational engagement was associated with contexts of study. For example, students in Finnish science classes were more likely to be situationally engaged when doing calculations and making presentations (Inkinen et al., 2019). However, gender issues regarding Finnish students' situational engagement in science learning has not been explicitly investigated.

There are also international programmes such as PISA that seek to understand gender differences in STEM subjects. According to a recent report (OECD, 2017), it has been found that on average, girls' performance in science is four points lower than that of boys across OECD countries, and there are 24 countries and economies in which boys score significantly higher than girls in science. Although boys across the world tend to be over-represented compared with girls in terms of both high and low performers, Finnish girls outperformed boys in science subjects, regarding both average scores and the number of top performers. For example, according to the PISA 2015 results, Finnish girls' mean science performance score is 15 points higher than for boys. In addition, Finland is the only country (among 33 countries and economies) that has significantly more girls than boys among the top science performers, despite the fact that the proportion of top performers in science is usually larger in boys than girls (OECD, 2017). Based on the high level of educational performance in STEM domain subjects and overall gender equality, some argue that Finland is poised to close the STEM gender gap (Stoet &Geary, 2018), even though there is still a large gender gap in STEM fields at university. The correlations between attitude and achievement were significant for both males and females, but such a link was stronger in females than in males (Sorge, 2007).

Looking back, it seems that the gender difference topic has been explored so explicitly that there is even concern today that it may cause bias about men's and women's learning ability (Collins et al., 2000). Such bias leads people to be more concerned about girls' engagement in science subjects and their uptake of occupations in STEM areas. In the past 20 years, educators have been working consistently to encourage more females to participate both in and out of school science activities through programmes like *Women In Science and Engineering* (WISE) (https://www.wisecampaign.org. uk) in the UK and *Project Access* (https://projectaccess.org/intro) in the U.S. Previous researchers have sought to answer the gender differences questions from a range of perspectives such as using aspects such as biological characteristics like the inadequacy of female scientists as role models, the female lack of academic readiness, and science pedagogy and curriculum favouring boys more. However, a critical review by Clark Blickenstaff (2005) rejected some of these arguments, and which led to the conclusion that overemphasis of the gender gap may disengage girls from entering STEM related fields. There have been few studies on gender differences in online learning to challenge the current stereotypes about women in online learning due to either improper research methodology (Crawford & Chaffin, 1997; Müller, 2008) or publication bias (Richardson, 1997; Price, 2006). In an empirical study, Price (2006) questioned the existence of gender differences, and paid special attention to women's engagement, performance and situations alike. He found that women did equally well in online learning and even outperformed their male counterparts in some aspects and he suggested that there be a shift of research focus to other worthwhile aspects.

Based on the literature on science engagement and individual differences, this study assumes that:

- H3a1 *Boys report higher levels of self-efficacy than girls.*
- H3a2 *Boys report stronger feeling-related interest than girls in science online learning.*
- H3a3 *Boys report stronger value-related interest than girls in science online learning.*
- H3a4 *Girls perform better than boys in science online learning in terms of knowledge tests (pre & post).*
- H3b *Boys are more situationally engaged than girls in online courses.*

2.5.2 Grade difference and similarities

School grades can be an important factor of students' engagement. To begin with, students' transition from lower secondary to upper secondary school is described with academic difficulty, motivation loss, and frustration (Barber & Olsen, 2004; Benner & Graham, 2009; Eccles & Roeser, 2009). Therefore, lower secondary school students (second and third year lower secondary school students) are more likely to regard the academic challenge as a threat than their upper secondary counterparts, as the latter have been through the selection process successfully and are more academically motivated. Secondly, since the upper secondary students are more academically motivated (especially among those with university aspirations), this period is somewhat crucial for them to shine in their transition to university (Strati et al., 2017). Based on these two justifications, it is hypothesized that the 11th graders will report higher levels of science engagement in response to challenges. In a formative analysis of students' differences in learning objects, self-efficacy, and performance, it was found that, in general, 12th grade students outweighed their grade nine and grade ten peers in terms of self-efficacy and science learning performance (Kay & Knaack, 2008). In addition, science students manifested a better attitude to learning and better outcomes than mathematics students. Lastly, students with a higher level of self-efficacy tend to value learning objects more than their less-confident peers, but such self-efficacy does not affect learning performance.

However, few studies have examined grade difference on topics such as science situational engagement and personal interest. In Singapore, science enjoyment was found to be higher among students in l4th grade than among students in higher grades (5th and 6th grade) (Peer & Fraser, 2015). A similar pattern has also been found among secondary school students. For example, in the study by Akpınar et al. (2009), science attitudes such as enjoyment was higher among lower grade students, and it tended to decline in the later years of lower secondary school.

Similar patterns were found in other countries. For instance, significant differences in enjoyment and the value of science were identified in the U.S. between students in 6th to 8th grade, in favour of 6th grade students (Weinburgh, 2000). In terms of interest, there is evidence that domain specific interest (i.e., physics interest) increased from the 9th to the 10th grade, indicating that upper secondary students may be more interested in science learning than their counterparts in lower secondary schools (Krapp & Prenzel, 2011). Longitudinal studies on K12 level school science education (since 1970s) has found that as students' age increases, its relationship with science performance increases, but such a relationship with science attitude decreased (Hassan & Fisher 2005; Littledyke, 2008; Sorge, 2007). A content analysis of 40 articles focusing on online learning engagement identified only seven articles that dealt specially with MOOC engagement. In addition, only three articles reported on secondary school students as the sample (Yang et al., 2018). Not much effort has been devoted to the study of individual differences and similarities in terms of online learning engagement (e.g., MOOC) and other associated factors. Therefore, there is a need to study students' individual differences in an online learning environment.

Based on the review, this study assumes that:

- H3c1 *Lower secondary school students report a higher level of self-efficacy than upper secondary school students.*
- H3c2 *Lower secondary school students report a stronger feeling-related interest than upper secondary school students in science online learning.*
- H3c3 *Lower secondary school students report stronger value-related interest than upper secondary school students in science online learning.*
- H3c4 *Upper secondary school students performed better than lower secondary school students in science online learning in terms of knowledge tests (pre & post).*
- H3d *Lower secondary school students are more situationally engaged than upper secondary school students in online science learning.*

3 THE PRESENT STUDY

3.1 The conceptual framework

Figure 3-1 shows the conceptual framework based on the hypotheses and research questions, drawing from the literature review. Although the framework was depicted in the Introduction, in order to let readers know what the present study is about, it is necessary to introduce it again, in a clear manner. First, the blocks entitled *factors and situ-engagement*, refer to the first research question: Are self-efficiency, attitude to science, and performance positive predictors of online learning situational engagement? The relationships between situational engagement and predictors such as self-efficacy, attitude to science, and knowledge were investigated from a broader perspective. Situational engagement is determined by interest, level of skills and perceived challenge. In order to be engaged, each of the determinant must be at least three on a five-point Likert scale questionnaire. In other words, a student needs to report a score equal to or higher than three on all properties (interest, skill, challenge). Based on this criterion, situational engagement was treated as a dichotomous variable that defined by either 0 (disengaged) or 1 (engaged).

In the block entitled *course context,* in this study, I probed the context of the course and how it affected students' level of engagement during the MOOC session, which is related to the second research question: Have time and course contexts in online learning (such as in a MOOC) had an influence on students' level of situational engagement? During the MOOC learning, students were interrupted six times by a pop-up window asking about their level of engagement at that time. Those six measures represent three situations/contexts. Namely, situation one (*explaining a concept/model*), situation two (*contextualizing)* and situation three (*making a summary*). Levels of engagement were compared across different situations. For example, will the *making a summary* part be more engaging than the section that deals with daily energy usage data (*contextualizing*)? Those will be more extensively described in the methodology chapter. Then in the last block, entitled individual difference, it investigates the differences in gender and grade in all the variables discussed above, which was connected to the third research questions. In addition, there is also the fourth research question that is not mentioned in the framework, it concerns the factors students reported as affecting their learning engagement (based on semi-structured interview).

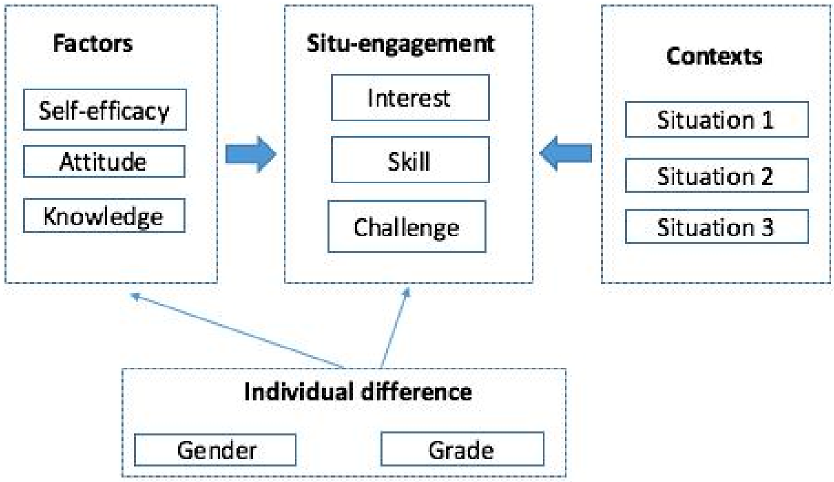

Figure 3-1. the conceptual framework of this study.

3.2 Context of the study

In this section, the structure of the MOOC is described step by step, and how it was planned, constructed, and its piloting tested is explained. Building a MOOC is an important part of this study, as we learnt that well-designed course material can foster students' engagement. In the follow section, I first explain how the course was reorganized and developed. The development of the MOOC was guided by the purpose of research. To inform readers about the whole MOOC design, the next section deals with learning environment development and MOOC pilot testing. For development of the learning environment, two major parts were presented: building learning materials, and design an online survey. Instruments have been introduced in a chronological order, along with the learning sequence. This will be followed by a course piloting session, in which emphasis was placed on how course and questionnaire were redesigned, based on the feedback.

3.2.1 The development of learning environment

Learning materials development

The platform for the MOOC was a university-based MOOC platform. This platform hosts more than 80 MOOCs and demos for university students and MOOC lovers alike. The Helpdesk staff from the IT department were responsible for administering the MOOC and cooperation issues, and for providing technical support for smooth platform operation. Below is a screenshot of the home page of the university MOOC platform.

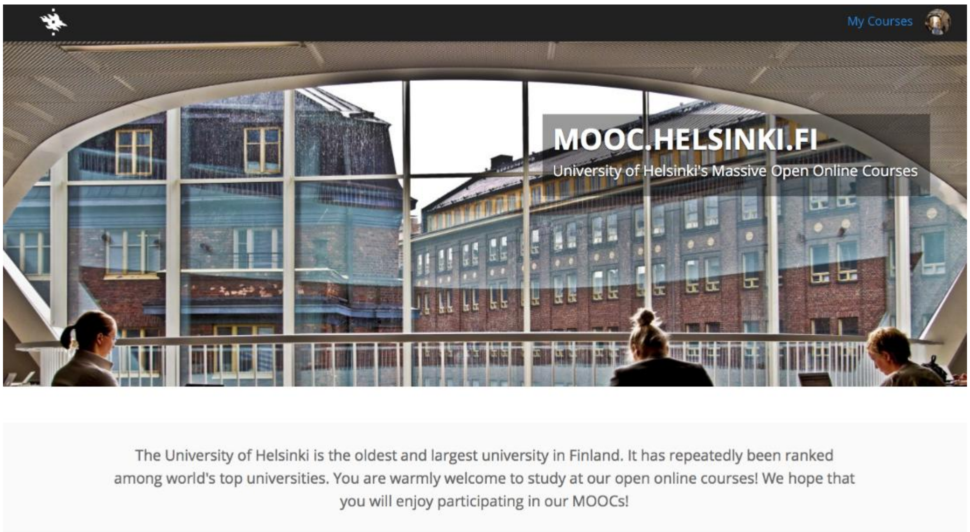

Fig 3-2. Screenshot of the MOOC platform utilized in this study.

The short course was adopted from an earlier MOOC that had been developed through a cooperative effort between the University Science Centre (LUMA) and science technology entrepreneurship (https://mooc.helsinki.fi/MOOC/index.php?categoryid=3), the topic of the course was sustainable development and energy efficiency. The original MOOC consisted of two sections (*a. Sustainable Energy, and b. Energy Efficiency*) with eleven video clips, the aim of which was to provide extracurricular self-learning materials for millennium youth across the world. In the *Sustainable Energy* part, examples of the topic were fusion, wind power, geothermal power and how they could be used in an eco-friendly way. In the *Energy Efficiency* section, topics such as the definition of energy efficiency, energy efficiency in city planning and what people can do in daily life in order to practise environmentally friendly behaviour. Overall, the original MOOC required ten days to finish. At the end of 2016, permission was gained from the MOOC designer and copyright holder and to tailor the original MOOC for the purposes of this study. After careful reviewing and planning, a reconstruction of the course was done by selecting appropriate video clips, modifying and reorganizing the existing material for this study.

Overall, three video clips totalling 45 minutes were used. Those three clips consisted of:

- CLIP ONE: an interview with the course teacher, discussing the topic of everyday energy saving practice. Overall length was 8:30.
- CLIP TWO: a video lecture on topics of sustainable energy globally and in Finland; City planning and how it is associated with energy saving. Overall length 20:30.
- CLIP THREE: a video lecture on the definition of sustainability and sustainable development; sustainability science within a divided world; themes, boundaries, time, space related to sustainable development, etc. Overall length 15:30.

Choice of the three clips was based on the following considerations. First, since the main interest in this study was about students' situational engagement in online learning and related factors, therefore, one 45-minute lesson seemed adequate for measuring students' level of engagement in a range of MOOC situations. Second, even though it was only 45 minutes, it included three parts, which varies in contexts and contents. Moreover, the design was consistent with the research purpose and design, a short MOOC that offered variety for the purpose of comparing engagement in different contexts. In addition, according to previous suggestions for better situational engagement in the classroom, providing vivid MOOC contexts and avoiding obscure content helps students to engage more in subject activity (Schraw et al., 2001).

The videos were chosen following a discussion with a group of experts and according to the selection criteria indicated below:

- The length of one video-clip was from five to twenty minutes, representing different topics, in order to compare level of situational engagement across various situations.
- There were different video presentation or interaction styles, i.e., "talking head" style, with only a background voice with PowerPoint, or interview style.
- The videos featured different teaching styles (i.e., on aspects like speaking rate, language skill).

Next, considering that the experiment was to be conducted with local Finnish 8th-11th grade students (in the Finnish education system, the second year of lower secondary school to the second year of upper secondary school), and the original video was in English and without subtitles, Finnish subtitles were added for better understanding. Plug-in software called H5P was implemented to insert pop-up questions into the original video clips. H5P has been a stable tool for creating pop-up texts and multiple-choice questions for purposes of teaching and researching (Rekhari & Sinnayah, 2018). This plug-in software was chosen because it is user-friendly and easy to start. In addition, it enables interactive videos and creates richer HTML5 content on existing publishing platforms and can share content seamlessly across any H5P-capable site and people can reuse and modify content at any time, if needed.

All videos were uploaded to YouTube first, then connected with the platform via URL links. It has been customary practice to upload MOOC videos to famous video hosting platforms like YouTube and Vimeo, and then to connect it with MOOC platforms (Guo et al., 2014). Previous studies have revealed the potential of using interactive video in MOOCs. Students reported that a MOOC with interactive modules such as pop-up questions is useful, more engaging and helps avoiding passive viewing of videos (Kolås et al., 2016, September). In addition, it increases the level of retention (Shelton et al., 2016), and speeds up the skills acquisition process when compared to standard videos (Schwan & Riempp, 2004).

The instruments development

The interactive video feature was enabled to create pop-up questions that measure situational engagement. Then those pop-up questions were associated with an powerful and steady online survey website (https://www.qualtrics.com), a reliable education experience management tool. Each time students click the pop-up question window they were directed to a new window which showed the questions to answer on Qualtrics. The screenshot of the pop-up question and the linked survey page is shown in Fig. 3-3.

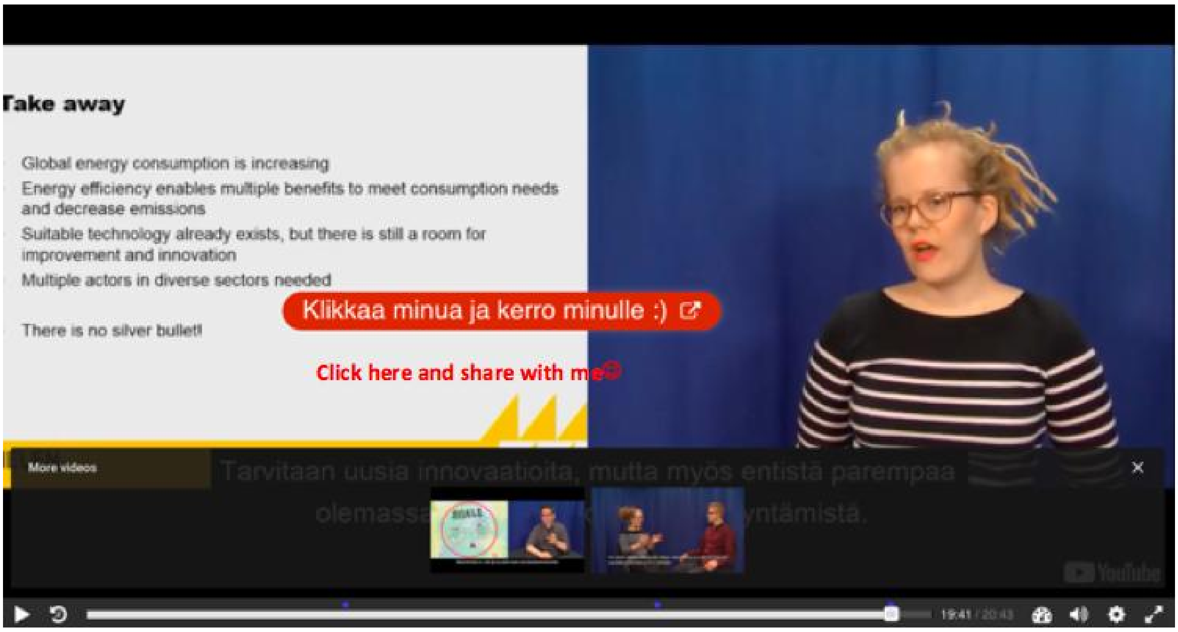

Fig 3-3. The icon of pop-up question as appeared in video.

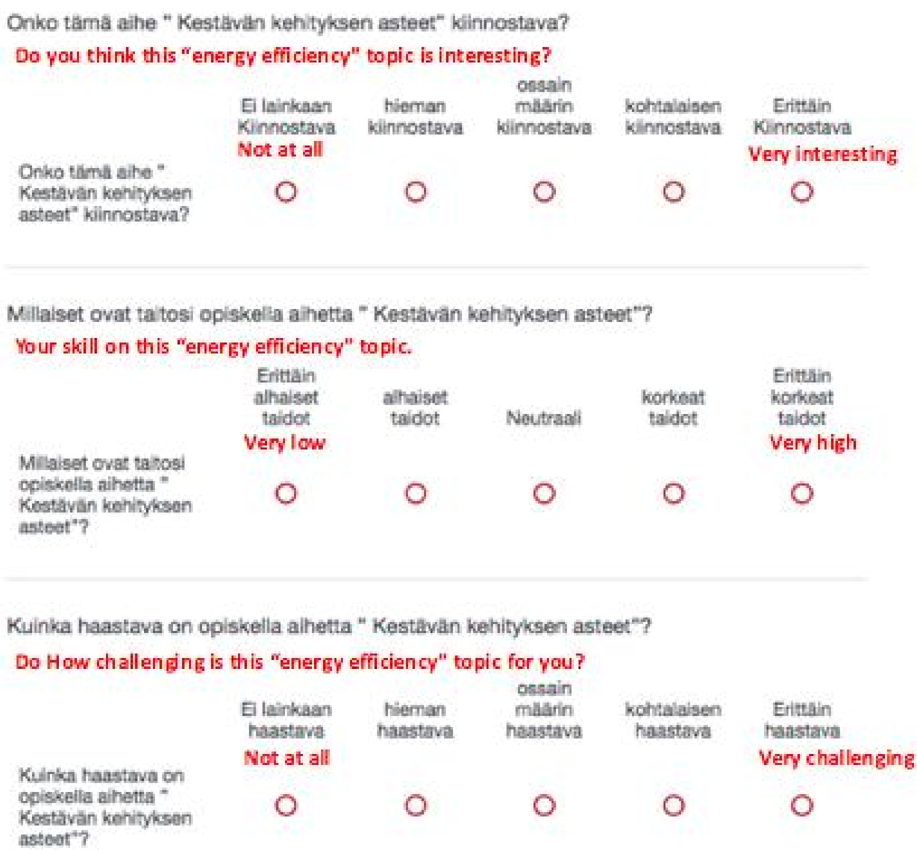

Fig 3-4. Example of online questionnaire item.

The learning materials were on the topic of sustainability and energy efficiency. This domain of knowledge was chosen because topics such as sustainable development were emphasized in the national curriculum and it is assumed to be both interesting and important knowledge for secondary school students. A science learning task was developed to the exam level of situational engagement across lower and upper secondary students at several Finnish schools. In the next section, a chart describing the process of learning activity is presented first (Fig. 3-5), followed by a chronological introduction to the instrument development process. All together there were five parts, an introductory section, a pre and post-test, a 45-minute MOOC video, and a semi structure interview after the MOOC.

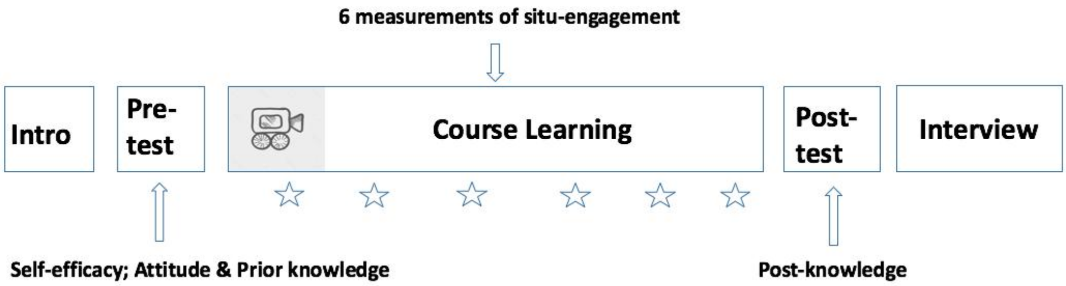

Fig 3-5. the design of learning sequence

Pre-test section

After logging into the university MOOC platform, students were guided to the course introduction page where a basic introduction of the course was provided. This included brief welcoming words, the registration guidelines of the course, plus how to participate, and to answer the pop-up questions properly. On the same screen there was a link which led to a separate page to collect information on the students' gender, grade and age. Before they started the learning session, there was a nine-item question to gather information on science self-efficacy, which had been adapted from the Motivation Strategies for Learning Instrument for an earlier study (Pintrich & Degroot,1990), with minor modifications. This was followed by a questionnaire seeking information on students' personal interest in science, which consisted of two parts: enjoyment (or feelings-related interest) and value of science (or value-related interest). Both were adapted from the PISA Student Questionnaire by the OECD (OECD, 2005). Students were asked to answer questions using a seven-point Likert scale which ranges from "not at all true for me" to "very true for me". In addition, there was a four-item science knowledge test which aimed to test students' previous knowledge storage. Science knowledge questions were selected from a question bank as built by the course lecturer, and items were chosen based on a piloting test. The answers with the most variety were selected.

Situational engagement test section

This second part was the learning session, which consisted of learning materials. Overall, three course video clips, and several sets of ESM measurements (using pop-up questions) seeking information on students' situational engagement were used. The ESM measurements appeared six times, with situational interest, skill, and challenge as the preconditions. It took only ten seconds to finish each pop-up question, as the goal was to measure students' situational engagement without disturbing the learning flow. Interest, challenge, and skills were assessed using a five-point Likert scale that ranged from *very low* to *very high*. This study approached situational engagement in a manner similar to the ESM and extended it to collect data in an online learning environment. This approach generated quantitative evidence, which is considered to be objective and reliable, and has been applied to educational and psychological research (Csikszentmihalyi & Schneider, 2000; Larson & Csikszentmihalyi, 2014; Schneider et al., 2016). In the ESM questionnaire, five-point Likert scale items were used to measure students' situational interest, skills, and challenges. Specifically, design of the six in-situ probes was based on the intended measures of different situations and on assumptions, thus it is able to know the situational engagement level reported by studens and how they fluctuated across different situations. In addition, some contexts may engage students more, while others engage them less.

Post-test section

After the MOOC session, students' science knowledge was measured again with the same questions as those in the pre-test. In addition, a semi-structured interview was conducted, to understand their situational engagement in more detail. More information on the questionnaire and sources can be found in the methodology chapter. The purpose of having a post-course knowledge test is to gather information on changes in students' knowledge, and to check if it was associated with students' engagement. A semi-structured interview of about 50-minutes' duration was conducted with five volunteer students. The interview was organized to obtain more information from students' discussion and avoiding leading to the results. Research permission was obtained from the City committee, and parental consent was also obtained before the interview. First, students were encouraged to discuss their thoughts and experience on the MOOC, which aspects they liked and disliked, and what their expectation would be if they did it again in future. Secondly, students shared their experience of engagement, describing it from their own understanding. In addition, students' preference for online learning was sought, for example, the MOOC presentation style, online or classroom science learning.

Pilot testing the MOOC

A pilot test was conducted after the preliminary learning environment was developed. To begin, a group of experts (N=5) were involved in testing the quality of the MOOC, its suitability for secondary education, and the readability of the text content. In addition, a group of students (N=30) from two local secondary schools participated in the MOOC. The purpose of the pilot testing was to find out:

- If the MOOC can be completed properly, and questions can be answered and collected correctly.
- If the number of questions in questionnaire is appropriate for students to answer.

- If the time allocated (around 65 minutes) is enough for students to finish the MOOC.
- If any improvements are needed (e.g., technical support)

Before conducting the pilot testing on students, five colleagues were invited to try out the MOOC first. They come from the author's own faculty (N=3) and another university focusing on engineering and technology (N=2). All had previous experience in teaching. They were guided to register and went through the MOOC, then feedback and suggestions were sent via email. The general feedback is indicated in the Table 3-1.

During winter 2017 the author started to prepare the pilot test. In February 2018, 30 students from a local teacher training school participated in the course, students came from the 10th (N=13) and 11th (N=17) grades. Sixty-five minutes were provided to perform the task. The participants had a range of competencies. The teachers looked at the MOOC beforehand and they thought that there was enough time. Before the MOOC, teachers spent 15 minutes presenting and demonstrating the procedure, then students were allocated 50 minutes to watch MOOC videos and answer the questions whilst watching. The teacher observed and followed the students' process. After the class, the teacher collected feedback from students and then sent pilot test results via email. Comments collected from the pilot test were summarized in Table 3-2.

Surprisingly, it turned out that the time was not enough, and most students took more than one hour to finish. In addition, result revealed that students were bored with the questionnaire at the beginning, which took too much time and there was a big portion of missing data. The difficult level was varied, but overall students reported a lower-than-average challenge on the MOOC. Such feedback means that some changes were needed, to make MOOC more engaging.

Table 3-1. Pilot test feedback from colleagues.

Tech issues	**Registration**	**Video content**	**Questionnaire**
I.e., can skip section/content easily	Long process	Audio track in English, no Finnish	Too long, which takes too much time

Table 3-2. Summary of feedback from teacher

	Aspects	**Problems being**	**Example**
Feedback	Time allocation	Insufficient	"only a few did everything..." "it took more time than expected"
	Guidelines	Not clear	"Some saw the videos and questions but did not provide the initial information about themselves"
	Questionnaire	Too many questions	"There are so many things to read and questions."

As shown in Tables 3.1 and 3.2, feedback from colleagues focused on the MOOC support parts such as the relatively long registration process, no subtitles in the students' native language, and taking too much time to complete the questionnaire. The teacher reported similar problems such as too many questions to answer which required too much time. In addition, the pre-designed guidelines for course enrolment were not working properly in the pilot testing, as some students did not notice the requirements. For example, before the MOOC starts, students are asked to fill in a questionnaire about their general view of science and self-efficacy about the MOOC, but some of them skipped it directly. This may also have been due to improper MOOC design. Also reported by teachers was the time allocation: 50 to 60 minutes was simply not enough.

After a careful discussion based on all the feedback, the team decided to redesign the MOOC accordingly. First, it was agreed that the questionnaire with too many items and insufficient time to complete it is the same problem. Since it is not desirable to make students feel bored at the beginning, cutting the items in the questionnaire became necessary. For the technical problems, to prevent students randomly skipping and avoiding questions, the logic of answering the questions was reset, and students were forced to answer all questions (but this only applied to the second round of data collection), which meant they could not continue before answering all questions. Another modification was to simplify the registration process. Instead of asking students to sign up and log in using email, a course code was set so that participants could enter the code to start the MOOC. In addition, a translation of the English text was made, and all necessary words were also shown in Finnish, including the questionnaires and explanations. Lastly, more time was allocated for students to finish the MOOC (around 70 minutes), based on the feedback collected from trials.

Table 3-3 shows the modified features of the MOOC based on the course pilot testing.

Table 3-3. Course redesign based on feedback.

Problem reported	For example	Modifications
a. **Tech issues**	Can skip questions easily &	Forced to answer every question
	Long registration process	Easy access via code invitation
a. **Content issues**	Too long questionnaire at the beginning &	Avoid too many questions before MOOC & cut several pre-test items
	No Finnish audio track	Add Finnish subtitles to video
c. **Time issues**	Fifty minutes not enough	Allocate at least seventy minutes

The science teacher also gave feedback in the following way:

> The students tested the MOOC yesterday. In the group there were 20 pupils and they had different competencies (variation). About 50 minutes was allocated to the MOOC. The teachers watched the MOOC beforehand and they thought there was enough time. However, it took more time than expected. Well-behaved students filled in all boxes and the "tell us about yourself" section carefully and this took them up to 30 minutes.

> Only a few did everything. Some saw the videos and questions but did not provide the initial information about themselves. If I did, I would allow 75 minutes, so that the experiment would not be finished, and I would say that they will do it as soon as possible. There are so many things to read and questions. Unfortunately, we did not have the time to do it until the end (Science teacher A).

Based on all the feedback collected, the team decided to cut the number of questions in the questionnaires and in the pre- and post-knowledge tests. This resulted in a reduction of four items in the knowledge tests: four items for feeling-related interest and five items for value-related interest. With reduced numbers of items, it was expected that students would have enough time to spend on course learning. Since starting with easy quizzes may lead to higher motivation for completing the rest, in this study the easier questions were presented first. Improvements were based on all the feedback. The method (4.2 & 4.3) described details such as how participants were recruited. To sum up, based on the pilot testing, the course design was improved, and the following changes were made:

- Reduced the number of questions and allocated a longer time for MOOC learning.
- Fixed several technical issues: a, set enforced answering of questions; b, enabled a faster registration process.
- Added Finnish subtitles to course videos.
- Improved the students' guidelines for the course.
- Reorganized the order of the knowledge test, etc.

3.3 Research questions and hypothesis

To sum up, there are three main research questions. Based on these main questions and the literature review, 15 hypotheses were formulated. The main questions and individual hypotheses were summarized as follows. To make the texts more readable, the hypotheses were presented right after each of the core questions. Situational engagement is the core concept in this study, and all the research questions were based on it. The first main question regards the factors that may be associated with online learning situational engagement, and self-efficacy, attitude towards science (i.e., feeling-related and value-related interest) and pre-knowledge were chosen as the hypothesis factors for testing; Second, the relationship between different situations or contexts of the course and students' level of engagement were examined. Specifically, the levels of situational engagement under three independent situations were compared. Finally, differences and similarities among students were investigated via perspectives of gender and grade. Table3-4 (as shown next page) illustrates the research questions and the related hypotheses this study was concerned with.

Table 3-4. Summary of core research questions and related hypothesizes

Driven questions	Hypothesizes
RQ1 How is secondary students' online learning situational engagement predicted by the factors of self-efficacy, feeling-related interest, and value-related interest?	H1a *Students' self-efficacy is a positive predictor of situational engagement in online science learning.* H1b1 *Students' value-related interest in science is a positive predictor of online science learning engagement.* H1b2 *Students' feeling-related interest in science is a positive predictor of online science learning engagement.*
RQ2 What influence do time and course contexts have on students' level of situational engagement in an online learning environment?	H2a *There is a significant time effect on students' level of situational engagement / students' situ-engagement level were fluctuated during the six-time measurement.* H2b *Daily life context of a MOOC is more engaging than other contexts (such as section summary and concept explanation).*
RQ3 What are the gender and grade differences in the lower- and upper secondary schools in terms of student's reported situational engagement and related variables in a science MOOC environment?)	H3a1 *Boys report higher level of self-efficacy than girls.* *H3a2 Boys report stronger feeling-related interest than girls in science online learning.* *H3a3 Boys report stronger value-related interest than girls in science online learning.* *H3a4 Girls report performing better than boys in science online learning in terms of knowledge test (pre & post).* H3b *Boys are more situationally engaged than girls in online courses.* H3c*1 Lower secondary school students report higher level of self-efficacy than upper secondary school students.* *H3c2 Lower secondary school students report stronger feeling-related interest than upper secondary school students in science online learning.* *H3c3 Lower secondary school students report stronger value-related interest than upper secondary school students in science online learning.* *H3c4 Upper secondary school students performed better than lower secondary school students in science online learning in terms of knowledge test (pre & post).* H3d *Lower secondary school students are more situationally engaged than upper secondary school students in online science learning.*
RQ4 What are the aspects and themes that affect students' situational engagement in a science MOOC environment	*N/A*

4 METHODS

4.1 Overview

The purpose of this doctoral study was to measure situational engagement in an online learning environment, along with the factors that could be associated with it. In addition, individual differences and similarities in engagement and the other variables were examined. A mixed method approach was applied. First, the quantitative approach was to collect data electronically via Qualtrics, an online survey tool. In addition to the survey is a semi-structure interview that was conducted after the MOOC. A semi-structured interview was also conducted, the purpose being to understand students' overall experience with the MOOC, including their preferences about the course, and factors that affected their online learning engagement. The use of an interview provided useful information on what makes a MOOC engaging and disengaging. The combination of surveys and a semi-structured interview enabled me to investigate the situational engagement both from a general view and an individual (and social) perspective. In terms of research paradigm, the former tended to be located within the positivist paradigm which emphasizes that empirical or analytical approaches is important, that formulation and testing of hypotheses is necessary, and that the truth or knowledge is yet to be discovered by research (Fadhel, 2002; Neurath, 1973); while the latter approach is loosely located within the interpretivist paradigm, underneath it believes that realities are social-constructed and multi-faceted, that it is also necessary to understand an phenomenon from individual level, that context is of great importance for knowing and knowledge etc. (Morgan, 2007; Kivunja & Kuyini, 2017).

In the next section, details on how the study was conducted will be presented. The section has been structured in four parts. First, participants (both survey participants and interviewees), provided demographic information. The second part was instruments, and here, materials such as questionnaires, interview protocol were depicted separately. The third part was about data collection, in which how the quantitative data and interview were conducted, was introduced in a detailed way. The final part (section 4.2.4) describes how research data were analysed. Methods applied in analysing the survey data and semi-structured interviews are depicted in this section.

4.2 Participant

4.2.1 The survey participants

Overall, there were 197 student respondents from four schools in metropolitan areas of Finland. For the final analysis, four cases with students' gender reported as "other" were deleted since they represented a low statistical power. As a result, a dataset consisting of 193 cases was used in the data analysis. The students' ages ranged from 14 to 18 years (M= 15.3, SD=.99). Specifically, the sample comprised 153 lower secondary school students (79.3%), and 40 second year upper secondary students

(20.7%). All schools are located in regional areas of two cities. Altogether, 50.3% of students were male (N=97) and 49.7% were female (N=96). Table 4.1 illustrates the details about participants.

Table 4-1. Demographics of survey participants

	First round	Second round
Gender		
Female	45(48%)	51(51%)
Male	48(52%)	49(49%)
Lower secondary school		
8^{th} grade (second year)	41(44%)	0
9^{th} grade (third year)	12(13%)	100(100%)
Upper Secondary school		
11^{th} grade (second year)	40(43%)	0

4.2.2 the Interview participants

Table 4-2. Demographic details of interviewees

Participant (ID)	Gender	Age	Grade
S1-11B1	Male	17	11^{th} (second year of upper secondary school)
S2-08B1	Male	14	8^{th} (second year of lower secondary school)
S3-11G1	Female	17	11^{th} (second year of upper secondary school)
S4-11B2	Male	18	11^{th} (second year of upper secondary school)
S5-08B2	Males	14	8^{th} (second year of upper secondary school)

Note: S1-11B1 = Student 1 from 11^{th} grade, gender Boy No.1

Besides a survey, this study also involved a semi-structured interview with five student volunteers who also participated in the MOOC. All five students came from one school in a metropolitan area of Helsinki, but from different grades. Among them, three came from 11th grade (which is the second year of upper secondary school in Finland), with two boys and one girl on board (M_{age}= 17.3); another two came from the eighth grade. (In the Finnish context: the second year of lower secondary school). Both were boys (M_{age}=14). Taken together, participants' age ranged from 14 to 18 years of age (M_{age}=16, SD= 1.87). For convenience of conducting inductive analysis and for easy reporting, all the participants were coded properly. For example, the first male students from 11th grade were coded as "S1-11B1" (see Table 4-2); the third participant, a girl from 11th grade was marked as "S3-11G".

4.3 Instruments

4.3.1 The survey questionnaires

Table 4-3. The questionnaires this study was concerned with

Questionnaires	Items (examples)	References
Self-efficacy (9 items)	Compared with other students in this class I expect to do well. I'm certain I can understand the ideas taught in this MOOC. I expect to do very well in this class.	Pintrich & Degroot, (1990)
Science attitude (9 items)		OECD. (2005)
Feeling-related interest (5 items)	I generally enjoy learning Physics / Chemistry	
Value-related interest (4 items)	Physics / Chemistry is important for helping us to understand the natural world Physics / Chemistry is relevant to me personally	
Situational engagement (3 items * 6 times)		Schneider et al. (2016) &
Pre-conditions for situational engagement: Interest Skills Challenge	Is this topic/section interesting for you? How you rate your skills in this topic/section? How difficult is this topic/section?	Inkinen et al. (2019)
Science Knowledge (pre & post) (4 items)	Which of the following statements is incorrect? (Choose one) a. Promoting sustainable development is only a technological issue b. An environmentally friendly product can be a more expensive option if you consider the lifetime of the product c. Promoting sustainable development is also a social issue d. Authorities have an important role to play in promoting sustainable development by limiting consumption choices to legislation	MOOC Question bank as created by course lecturers. (2016)

This section introduces the questionnaires that were applied in this study. Firstly, Table 4-3 illustrates two blocks of questions: one block on variables associated with engagement (self-efficacy, feeling and value-related interest, and knowledge) and another comprises ESM questions on situational engagement (that including six context-specific measurements of situational interest, skills, challenge). In addition, examples of questionnaire being used, and relevant references were given. Secondly, a brief explanation on how those items were adopted to fit this study was also provided. This was followed by a description of the pop-up questions which measure engagement in MOOC contexts. In addition, Table 4-5 illustrates the times when ESM questions appeared in the MOOC, along with the corresponding contexts of the course.

Table 4-3 presents the questionnaire and how it fitted with the contexts of our study. The first set of questions appeared before the science MOOC, including a nine-item questionnaire measuring students' science learning self-efficacy, feeling-related interest, value-related interest, and four questions measuring science knowledge (pre-knowledge test). The second set of questions was implemented into the MOOC videos, which are the EMS measures. All questions emerged in the form of pop-up questions, measuring situational engagement across three contexts/situations (including: explaining a model-concept, making a summary, and contextualizing, see Table 4-4 for more detail). The third set of questions appeared at the end part of the study, measuring only science knowledge, with the same questions used for the pre-knowledge test. Table 4-3 provided a summary of the questionnaire that was used for this study. In the follow section, each set of questionnaires was introduced separately.

Self-efficacy is a nine-item questionnaire adopted from Motivation Strategies for Learning (MSLQ) (Pintrich & Degroot, 1990) with minor modifications. The original MSLQ is an 81-item questionnaire that measures various indicators about a specific course or domain (Pintrich et al., 1991, 1993). Questionnaire items were modified slightly to fit to the context of this study. Examples of self-efficacy items are: "I believe I will receive an excellent grade in this MOOC"; "Considering the difficulty of this MOOC, the teacher, and my skills, I think I will do well in this class". Students were asked to fill in this self-efficacy questionnaire before they browsed the MOOC videos. They answered by ticking the appropriate box on a seven-point Likert scale, the extreme categories being "1 = not at all true of me and "7 = very true of me. According to the authors, those items in the questionnaire were revised over multiple administrations in educational psychology classes at the University of Michigan between 1982 and 1986 (Pintrich & Degroot, 1990). In addition, MSLQ have been adapted to many versions and validated in other languages in countries like Turkey, and China (Lee et al., 2010; Karadeniz et al., 2008). Bandura has also provided guidelines on how to use self-efficacy instruments properly across various activities and different domains, such as car driving self-efficacy and game playing self-efficacy. However, the focus of on self-efficacy in academic settings, and to be specific, science learning self-efficacy. Cronbach's alpha reliability for self-efficacy was very good at .955 (Nunnally, 1978).

Feeling and value-related interest in science. At the starting point of the MOOC, students were given a questionnaire using items from the 2006 PISA Student Questionnaire (OECD, 2005). The original items concerned enjoyment of science and the perceived value of science, but in this study, they were adapted and interpreted from the perspective of personal interest (Schiefele, 1991). Based on the literature review on science attitudes and personal interest, the feeling-related interest and value-related interest variables were formulated. Those items were adopted from PISA questionnaires with minor modifications, and participants answered questions online. For example, to control the overall quantity of questionnaire items and avoid repetition, in this study it was decided to restrict use to several items from the afore-mentioned instruments. The Attitude variable consisted of two sub-variables, namely feeling-related interest and value-related interest in science. Therefore, two sub-variables can also be interpreted as enjoyment and value of science based on Bybee (2009). However, it is worth noting that for the attitude to science variable, this study was more concerned with the personal interest aspect (that is, it consisted of feeling-related and value-related interest), thus it was different from the interest in situational engagement, in which situational interest during a learning task was emphasized (such interest in situations was of concern in the situational engagement block of this study). Since several parts of the PISA questionnaire were used in this study, a test of reliability was needed. Overall, when treated as a one factor structure, the Cronbach's Alpha for variable attitude to science was good at .891, indicating good reliability based on the rule of thumb. Since in this study attitude was interpreted as consisting of feeling-related interest and value-related interest, Cronbach's Alphas for each were also computed. For feeling-related interest it was good at .878, and for value-related interest, it was acceptable at .713. Details regarding the reliability and validity of the scale will be presented in section 4.5.

Feeling-related interest questions were adopted from Question section 16 of the PISA 2006 student questionnaire, while value-related interest items were adopted from Question section 18 of the PISA student questionnaire (OECD, 2005). For value of science, five out ten items from the original were used in this study. Compared with other factors, those five items placed more emphasis on the “self” and “society” aspects of science, which are more relevant to the context of this study. Example items are “Natural science is very relevant to me.”, and “Advances in natural science and technology usually improve people’s living conditions”. Similarly, on feeling-related interest, only four items were chosen, to control the overall quantity. Although the items were taken from PISA, it was originally based on the enjoyment scale from the Achievement Emotions Questionnaire (AEQ) (Pekrun et al., 2005). In the questionnaire, students were asked, “How much do you agree with the statements below?” and the first item was “I generally have fun when I am learning science”. Example items of science enjoyment are “I generally have fun when I am learning science topics” and “I am happy doing science.” All answers were saved automatically to the Qualtrics online survey platform(https://www.qualtrics.com/uk). Students answered by ticking the appropriate box on a seven-point Likert scale for which the extreme categories were *Strongly agree* and *Strongly disagree*.

The items and scales are presented in Appendix 1. Items were classified in two groups. For example, the item "I am happy doing physics/chemistry problems (ST16Q03)" reflects feeling-related valences of personal interest and the item "I find that physics/chemistry helps me to understand things around me (ST18Q08)" reflects value-related valences of personal interest. The decision to use only five items for enjoyment (feeling-related interest) of science and five for value of science is that, based on feedback collected from pilot testing (see course piloting section). There seems be too many questions, which may have bored and influenced students' learning flow in the short MOOC. In addition, if too many questions were asked before the MOOC, learning motivation could be reduced drastically. Items based on a previous study that had classified those PISA items from the perspective of personal interest in this study (Lavonen & Laaksonen, 2009). In addition, because one purpose of this study was to know if the perceived enjoyment (or feeling-related interest) of doing science was positively linked with engagement, too many questions before a learning task may bore students, thus they might report a lower level of interest.

Situational engagement (as measured by situational skills, challenges and interest). As mentioned in the literature review, the definition of situational engagement in this study was based on flow theory and followed by the study of Schneider et al., (2016) that measured optimal learning moment from the perspectives of interest, skills and challenge. Schneider and colleagues extended the work of Csikszentmihalyi (2008) who defined "flow" as situation specific and combined the idea of Hidi and Renninger (2006) who argued about the role of interest as a psychological predisposition for a specific object. This idea and applying it to situational engagement in an online science learning environment has been borrowed for this study. Students' engagement in situations are simply assessed by asking about students' level of interest, skills and challenge in different contexts. This definition emphasized the cognitive and emotional aspects of engagement, regardless of the behavioural component. The situational engagement was measured with Likert scale items relating to situational interest, skills, and challenges, an approach assembled from Experience Sampling Methods (Csikszentmihalyi & Larson, 1987; Csikszentmihalyi, 2014). Instead of measuring engagement using long questionnaire items, in our study, simplified one-item rating scales were applied. Measuring 0 items of this type has been found to be effective, when items are clearly expressed and unblurred (Ainley & Patrick, 2006; Patrician, 2004). Around every eight minutes, a pop-up question emerged on the screen simply asking: "*Is the activity interesting?"; "Your skills in the activity"; and "Challenge of the activity*". Students answered the questions on a five-point Likert scale with the response categories *'very interesting'* = *5, 'interesting'* = *4, 'somewhat interesting'* = *3 and 'not interesting'* = *2, 'not interesting at all'* = 1. Situational engagement was determined by students' self-reported level of interest, skills and challenge, and a dichotomous variable consisted of one *('situationally engaged')* and zero *('not situationally engaged')* were based on the follow criteria: to be situationally engaged, students must have rated all of the questions related to skill, interest and challenge at three or higher (i.e., interesting or very interesting). Based on the criteria, it is possible to compute if they were engaged or not in a measurement point. It is also possible to calculate how many times students engaged across the six measures of time. The binary analysis approach was created by Schneider et al. (2016), and used in several follow-up studies (Inkinen et al., 2019; Inkinen et al., 2020). Overall, students are required to report six times during the MOOC on their level of interest, perceived skills and challenge in pre-settled contexts, in order to indicate how situational engagement changes in response to various situations. Similarly, a test of reliability was conducted on situational engagement questions, and the Cronbach's Alpha for variable situational engagement was acceptable at .710.

Table 4-4. Some features of video and pop-up questions.

Video	Probe	Time appearing	Context in situations
1	1	6 m 20 s	*Explaining a concept/model 1st*
2	2	6 m 18 s	*Contextualizing 1st*
2	3	13 m 56 s	*Contextualizing* 2nd
2	4	19 m 41 s	*Making a Summary 1st*
3	5	6 m 16 s	*Explaining a concept/model 2nd*
3	6	12 m 24 s	*Making a Summary 2nd*

Table 4-4 presents the information about ESM measurements and video feature such as the appearing time of pop-up questions, and the lecture contents/situations across the six measurements. As indicated, overall, three video clips which formed a 45-minute MOOC were used in this study. Six ESM measurements were administrated in the MOOC. Specifically, those six sets of measurement represented three situations or contexts of the course. For example, probe two, probe three and probe four were set in the second video, appearing at 6m 18s, 13m 56s and 19m 41s separately, and representing a MOOC context entitled Contextualizing and Making a Summary (See Table 4-4 for full information). It was assumed that sections in which teachers were contextualizing (i.e., connecting data on energy consumption in Finland) would be more engaging for students.

For easier analysis in later sections, the above-mentioned situational topics were classified into three categories: first, in probe number one and number five, lectures were either introducing an interesting energy-using model or explaining a new concept, thus those two measures were organized into one group namely Explaining a concept/model (SENG1), and this consisted of situation number one. Secondly, in probes two and three, in both sections teachers connected energy consumption with home heating in Nordic countries such as Finland, thus they used an approach such as *contextualized learning, thus this situation was* catalogued as the situation Contextualizing (SENG2), this is the situation number two. Finally, probes four and six were set at a point at which a section summary was presented, they were therefore classified as the group making a summary (SENG3), which was treated as situation number three. It is worth knowing that in some sections, situational engagement in different contexts/topics was presented using the abbreviated forms: SENG1, SENG1 and SENG3.

Science knowledge (SK). The science knowledge questionnaire consisted of a set of questions measuring students' knowledge of science. Some of the items were related to the content of the course (i.e., sustainable development), while others dealt with common science issues such as energy consumption and global warming. The original questions consisted of eleven multiple choices items, chosen by the author from the MOOC question bank, which was originally created by course lecturers. There was only one correct answer for each question, with students answering by clicking what they believe to be the right one and submitting all responses via the Qualtrics online survey tool. In this study, students' knowledge of general science was accessed both before (pre-knowledge) and after (post-knowledge) the short course, utilizing the same items. In the analysis section, science achievement was assessed according to science knowledge measured before and after the MOOC. Another purpose of having two pre-knowledge (PreK) and post-knowledge (PostK) tests was to investigate their connections with other variables such as level of feeling-related interest, value-related interest and self-efficacy (SE).

4.3.2 Interview protocol

A protocol for conducting the interviews was developed. The development of an interview protocol was based on The Interview Protocol Refinement Framework (IPR) as proposed by Castillo-Montoya (2016). The IPR framework has been tested in many cases, acted on as a reliable tool in terms of strengthening the reliability of interview protocols, and improving the quality of data obtained from research interviews. A four-phase process IPR was used in this study:

a, Ensuring interview questions align with research questions

b, Constructing an inquiry-based conversation

c, Receiving feedback on interview protocols

d, Piloting the interview protocol (Castillo-Montoya, 2016)

The next part introduces how the interview protocol in our context was developed following the IPR framework. It starts with the research questions this study was concerned with and ended with how the interview protocol was tested and piloted before it was actually used.

For the purpose of making the most of the students answer, the team first had a brainstorming session for the interview questions, then the proposed questions were evaluated by two experienced researchers. Changes were made according to comments and suggestions from the expert team. In addition, an interview protocol matrix was developed, to make sure that all interview questions were aligned with research questions. As indicated in Table 4-5, the matrix consisted of three parts: a script prior to interview which introduced the background and purpose of study; a section for reviewing aspects of the consent form; and three research questions that used as a guidance for interview.

The interview questions were based on the theories and three important pre-conditions of situational engagement: interest, skill and challenge. The interview deals with both general preference questions (such as what aspects the students liked or disliked) and specific ones (i.e. interviewee's preference for video production and teaching style), in order to find out the factors related to online science leaning situational engagement. The main question asked in the interview was: what was the student's experience with the MOOC in terms of learning engagement? Experience is important for semi-structured interviews so in-depth interview researchers are able to make meanings out of their stories. As Seidman (2013, p. 9) put it, "The purpose of in-depth interviewing is not to get answers to questions... At the root of in-depth interviewing is an interest in understanding the lived experiences of other people and the meaning they make of that experience... At the heart of interviewing research is an interest in other individuals' stories because they are of worth" (Seidman, 2013, p.9). The storytelling of experience of a short science MOOC can manifest how well one has engaged, and how contextual factors contributed to that experience.

Table 4-5. Interview Protocol Matrix for semi-structure interview.

<table>
<tr><td colspan="4">Script prior to interview:

I'd like to thank you once again for being willing to participate in the interview for my study. As I mentioned to you before, my study seeks to understand factors related with secondary school Finnish students' online science (situational) engagement. The aim of this research is to figure out the most important factors that affect their online learning engagement, thus provide guidelines to better course design. Our interview today will last approximately 45-60 minutes during which I will be asking you about your general experience of the course, the important factors related to your participation, and your personal preference etc.
[review aspects of consent form]
In class, you completed a consent form indicating that I have your permission (or not) to audio record our conversation. Are you still ok with me recording (or not) our conversation today? ___Yes ___No
If yes: Thank you! Please let me know if at any point you want me to turn off the recorder or keep something you said off the record.
If no: Thank you for letting me know. I will only take notes of our conversation.
Before we begin the interview, do you have any questions? [Discuss questions]

If any questions arise at any point in this study, you can feel free to ask them at any time. I would be more than happy to answer your questions.</td></tr>
<tr><td>Interview Questions #1:</td><td></td><td></td><td></td></tr>
<tr><td>What did you like and dislike about the course?</td><td></td><td></td><td></td></tr>
<tr><td>Describe a time when you really enjoyed and concentrated on your task.</td><td></td><td></td><td></td></tr>
<tr><td>What improvements are needed if you were to do the course again?</td><td></td><td></td><td></td></tr>
</table>

In the interview protocol, a variety of questions were asked. For example, when asking how students recalled their MOOC learning experience, questions such as "based on your experience, what did you think of the MOOC?" or "was the MOOC easy for you?" were used. The purpose is to start with an enquiry-based conversation, and encourage interviewees to share more. The interview protocol was then pilot tested with two Finnish students, who were encouraged to ask questions about unclear questions. The protocol was then further revised based on students' feedback. From the pilot testing it was learned that one important defect of the interview protocol was the missing of prompt questions, the presence of which enable in-depth interviewing of interesting facts. To that end, several likely follow-up and prompt questions were prepared before the interview by the researcher. Examples of these: why (do you think the course is challenging)? This is interesting, could you describe it more? For the interview protocol developed for interviewing students on their MOOC learning engagement and experience, please refer to Table 3-1. While the quantitative approach (i.e. survey) generated a larger dataset than the interview, the interview is crucial in understanding situ-engagement in-depth and in more details. It adds a new layer to knowing the important factors behind engagement and disengagement. What is more, the use of a semi-structure interview is more memory-based/retrospective while the online survey questionnaires are more in situational. They act together as a perfect match for understanding general engagement and situational engagement.

4.4 Data collection

This study followed the ethical standards of American Psychological Association (APA) for good research and collaboration, and the Finnish National Board on Research Integrity (TENK, 2019) guidelines for ethical principles of research. Permission was obtained from the school principals, teachers, and students. Teachers and students participated voluntarily and they could withdraw from the study whenever they felt like doing so. All data were made anonymous after collection. Interviewees were addressed by code names. Neither the results, schools, teachers nor students could not be identified in the research report. The data were stored securely and anonymously for two years after the last publication. The learning materials (i.e., MOOC) designed for this study conformed with the learning goals set by the 2014 National Core Curriculum (FNBE, 2014).

Because the participants were below 18 years of age, parental consent and student assent forms were obtained before the actual data collection. Emails were sent by the project manager to parents and guardians, which outlined the purpose of the study (to investigate key factors behind teenagers' online learning and situational engagement), what will be asked of participants (compete a one-hour online MOOC and response to questions and quizzes), social values of research, plus core research protections, such as confidentiality, risk and benefit of participation, and voluntary involvement. It was found that the study met the standards for conducting research with the young people who participated in an online science MOOC that had a theme in sustainability and energy efficiency. The short science MOOC was designed to investigate the context-based situational engagement and key factors that are associated with it. In addition, a debriefing statement was included that had contact information for the project manager if any participant experienced an adverse response to their taking part in the study.

4.4.1 The survey data

Survey data in the study were gathered in two rounds of data collection. The first round was conducted in spring 2018, when students from three schools participated. Due to a relatively large portion of missing data, a valid sample of 93 (specifically, 48 males and 45 females) was assembled. Of the students, 44% reported as eighth graders, 13% were ninth graders, whilst 43% of them were eleventh graders. A preliminary check of data found that the students at upper secondary school (11^{th} grade) were likely to report a relatively lower level of challenge in all the ESM measures. This information was important, as it revealed that the topic and content could be too easy for upper secondary school students. Taking that into consideration, the team decide to collect data from lower secondary school students (9^{th} grade). There are two justifications for such a decision. First, 9th grade was important as it is the last year of lower secondary school. By then, students' attitudes about and interest in science have been developed to a certain degree. Secondly, in the first round of data gathering, ninth graders were among the majority, and had the highest level of response rate. In autumn 2019, the second round of data collection was conducted. Compared with the first round, several changes were made. For example, different from the first round that students all participated without any form of compensation, in the second round, a cinema ticket was given to students who finished most of the questionnaire (e.g., completion rate >90%). Because the data collection was intensive, students were asked to answer the ESM questionnaire several times across the learning task, perhaps disrupting the flow of learning (Sinatra et al., 2015), so compensating the students of their participation is recommended, as suggested by Fredricks and McColskey (2012). As a result, an additional 100 valid samples were added to the dataset, making the total of 193 cases for final analysis.

The procedures were depicted as follows: Teachers from three schools agreed to use the one-hour MOOC as one of their school science teaching modules. The research team developed a MOOC enrolment instruction that detailed the MOOC registration procedure and MOOC demos. Before the actual MOOC, instructions for enrolment and guidelines were distributed by teachers. In addition, parents or guardians were notified by mail that the survey was to be conducted. Both the parents and the students were assured of their rights to optional participation and the confidentiality of students' responses. Students were asked to complete the video, quizzes and pop-up questions during the class. Answers were recorded and stored automatically by Qualtrics (https://www.qualtrics.com/uk/). From the Qualtrics webpage, students' answers were delivered to IBM SPSS Statistics 23 statistical software package using the comma-separated values (CSV) format. Data were reorganized and sorted if necessary. Since there were several individual measurements of situational engagement, an individual identification number was given to each student, enabling researchers to combine answers from six time points.

Overall, the dataset consisted of two parts, with the first part being an online survey, in which three blocks of data were included:

- Biographical data (i.e., age, gender, grade)

- Pre knowledge on science
- Self-efficacy and attitude to science (enjoyment & value); situational engagement during the task (six measurements); and post knowledge test after the MOOC (same as pre-knowledge).

The survey data were collected to provide answers for RQ1, RQ2 and RQ3, whilst the second part of the data set was qualitative data from the interviews, which were used for inductive analysis, and in response to RQ4.

4.4.2 The interview data

The role of the interviews was to collect students' opinions, experience and online science learning preferences. While some preliminary questions were written to guide the semi-structured interview, students were also encouraged to discuss topics in a broader perspective. The interview was conducted in the teachers' tearoom of one participating school. Interviews were recorded using an audio recorder. Permission was obtained before the actual interview, and participants' basic information (i.e., grade and age) was sought. Data were stored automatically in an .MP3 format file. Overall, a 24 Megabyte file was created. After the interview, the audio file was converted into a .TXT formatted file immediately. To ensure the quality, a transcription of the interview was conducted right after the interview.

4.5 Data analysis

This section starts with missing data handling. Since a substantial portion of missing data, a multiple imputation was conducted in order to compensate for the large missing portion. Some of the questionnaire items were organized in a seven-point scale (i.e., questions on self-efficacy and personal interest), while the rest of the questions were in a five-point scale (i.e., situational engagement), thus data were standardized before data analysis. This was then followed by an exploratory factor analysis (EFA) for questionnaire items on self-efficacy and personal interest (feeling-related interest & value-related interest). For self-efficacy, the EFA result identified only one component, and one question item were deleted (SE8) as a result of poor factor loading (<.40). After that, a section explaining how quantitative and interview data were analysed was presented, in accordance with the research questions and hypothesis.

4.5.1 Missing data

The problem of missing data is common in most studies, especially in online survey and ESM types of questionnaires. Missing data may affect conclusions drawn from the research data (Graham, 2009). According to Kang (2013), the absence of data presents problems such as reducing statistical power; causing bias in parameters estimation; reducing representativeness of samples; and complicating the analysis. It is even more common to have missing data for a study that collected data via the Internet. Since this study collected all the students' responses (quantitative) via an online survey tool, a medium to large portion of missing data was presented, especially from the first round of data collection.

Among the four blocks of questionnaires, the percentage of data missing for self-efficacy was 20.5%, and 18% for knowledge questionnaires and personal interest (feeling and value-related interest). In this study, students were not forced to respond to the pop-up questions on situational engagement, because i did not want to affect the participants' learning flow. As a result, the missing portion became increasingly greater from the first time ESM was measured to the sixth time ESM was measured (as students may be bored by having to repeat the ESM questions). Because the overall sample size was relatively small, simply conducting a list-wise deletion may lead to a drastic reduction of statistical power, thus I tried to find an alternative. I followed the common steps for missing data handling, and in this study, it was assumed that the data were missing completely at random (MCAR), so a MCAR test was performed by including all the variables studied. Little's MCAR test indicated that the missing was completely random, Chi-Square = 177.222, DF = 181, Sig. = .565, thus the missing pattern was missing completely at random was confirmed. According to Cheema (2014), multiple imputation (MI) is a reasonable approach for educational data with larger missing portions, it generally results in several complete sets of data by simulating the nature variations of data and imputing it several times. For medium-sized samples ($50<n<1000$), MI produces a better level of accuracy for common analysis such as T-test, Regression and ANOVA, when compared with mean imputation (EI) and expectation maximization imputation (EM) (Cheema, 2014).

Result robustness check. Since data imputation had been conducted, it is necessary to have a result robustness check using original data (use list-wise deletion). As a result, the main findings were retained. For example, secondary school students' science knowledge before and after the test were positively correlated ($r = .55$, $P<0.01$). There was also clear link between students' self-efficacy and feeling-related interest ($r = .41$, $P<0.01$), or value-related interest ($r = .50$, $P<0.01$). In addition, an independent sample T-test revealed significant differences between males and females on self-efficacy; $t\ (163) = 4.47$, $p < .001$; on situational engagement (times), $(106.47) = 2.43$, $p < .05$; and on value-related interest in science: $t\ (143.30) = 2.80$, $p < .01$. No significant difference between males and females was found in Science knowledge (pre- and post-test). Grade differences were also similar with imputed data: there were significant differences between lower secondary school students and their upper counterparts on both pre-knowledge test and post-test ($T_{pre}\ (89.6) = -3.82$, $p < .01$; $T_{post}\ (148) = -3.65$, $p < .001$), and on feeling-related interest ($t\ (72.17) = -5.21$, $p < .001$), or value-related interest in science ($t\ (86.91) = -5.20$, $p < .001$). Thus, it was concluded that the imputed dataset was reliable for conducting further analysis.

4.5.2 Validity and reliability of instruments

Structure validity was assured by conducting a series of exploratory factor analyses (EFA) using the maximum likelihood method (with direct Oblimin rotation). Initially, the factorability of the nine self-efficacy items was examined. Several well-recognized criteria for the factorability of a correlation were used. Firstly, it was observed that all nine items correlated at least .3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .946, above the commonly recommended value of .6, and Bartlett's test of sphericity was significant (χ^2 (36) = 1519.601, $p < .001$). The exploratory factor analysis resulted in only one component. Variable self-efficacy was comprised of nine items reported on a 5-point Likert scale that explained 100% of the variance with factor loadings from .284 to .865. Item No. eight "I want to do well in this course because it is important for me to show my ability to my family, friends, employer, or others." only has a factor loading of .284, which is less than .400, was deleted from the data (see Appendix 5). After items with poor loadings were deleted, the other eight items of SE explained 100% of the variance with factor loadings from .660 to .845. Indicating that the variable self-efficacy is proper. Reliability was assured by calculating Cronbach's alpha for self-efficacy; it was very good at .955.

Similarly, the same EFA was performed on variable attitude. This resulted in a one component structure. First, five out of the five items correlated at least .3 with one other item, indicating a reasonable factorability; the KMO measure of sampling adequacy was .831, which was above the suggested value of .6. In addition, Bartlett's test of sphericity was significant (χ^2 (6) = 452.259, $p < .001$). Variable attitude consisted of five items reported on a five-point Likert scale with factor loadings from .248 to .913. One item, shown communities of .248, which is less than the recommended bottom-line of .400, was deleted from the data. After an item with poor loadings has been deleted, the other four items explained 89% of the variance with factor loadings from .818 to .912. Cronbach's Alpha for variable attitude to science was good at .891. Even though variable science attitude was nicely extracted as a one-component factor, for the purpose of this study, a two-factor structure was also explored. As a result, two factors, namely feeling-related interest, and value-related interest were identified. The KMO measure of sampling adequacy was good at .831. Bartlett's test of sphericity was also significant (χ^2 (6) = 452.259, $p < .001$). Altogether, the two-factor variable explained 86.70% of the variance with factor loadings from .806 to .953. A follow-up check of Cronbach's Alpha for feeling-related interest was good at .878, for value-related interest was acceptable at .713. Thus, it supported the overall structure of the two-factor based questionnaire. For data analysis, this study applied the two-factor structure of attitude, thus I looked at the feeling-related interest and value-related interest separately.

Finally, an EFA was performed on variable situational engagement. As a result, three components were extracted, which explained 58.45% of the total variance. All items correlated at least .3 with one other item, indicating a reasonable factorability. The KMO measure of sampling adequacy was .842, which is beyond the suggested value of .6. In addition, Bartlett's test of sphericity was significant (χ^2 (153) = 1634.120, $p < .001$). Among all 18 items, factor loadings were from .358 to .633. Again, Cronbach's Alpha for variable situational engagement is acceptable at .710.

4.5.3 Analysis of quantitative data

The research questions and related hypothesis were presented in section 3.2. In this section I only introduce the analysis method applied for survey data (including the ESM data). Details of the interview data and how to analyse them will be presented in the next section.

Table 4-6. Analysis of quantitative data based on questions (RQ1, RQ2 &RQ3) and hypothesis

Driven questions	Hypotheses (examples)	Analysis method(s)
RQ1. Are interest, self-efficacy of, and attitude to science positive predictors of students' online learning situational engagement?	H1a Self-efficacy of science is positive related to situational engagement H1b1 Students' feeling-related interest in science is positively related to online science learning engagement. H1c Situational learning engagement positively related to students' science performance (as measured by knowledge test)	Pearson Correlations & Statistical descriptive analysis (i.e., M, SD & frequency)
RQ2. Will the level of situational engagement be affected by time and the contexts of the MOOC?	H2a There is significant time effect on students' level of situational engagement/student reported different level of situational engagement across the six-time measurements. H2b Student engaged more with online MOOC videos which deal more with daily life topic (contextualizing), compared with others.	Statistical descriptive analysis (M, SD & frequency) & repeated ANOVA analysis
RQ3. What is the individual difference (gender & grade) of students' online learning engagement?	H3a There are significant gender and grade differences in level of situational engagement, self-efficacy, performance, and science attitude. H3b There is significant gender and grade difference across all online situational engagement measures	Individual sample T-test & repeated ANOVA analysis

Note: RQ4 is not mentioned here, as it only related to the interview data.

All the analysis of quantitative data was conducted using the SPSS 23.0 statistical software package. First, the Kaiser-Meyer-Olkin measure of sampling adequacy was applied to all sets of questionnaires, and in order to evaluate the internal consistence of some groups of items, Cronbach's Alpha (α) was calculated for each group. For Hypotheses1a, 1b1, 1b2, and 1c, Pearson's correlation among factors and sum of situational engagement were calculated, to see how factors were related in either a positive or negative way. Then a hierarchal regression was performed, to examine which factors predicted students' situational engagement. To test the hypotheses 2a, 2a and 2c, the percentage of being situationally engaged were computed and compared across different groups (i.e., contexts of course). In addition, one-way repeated ANOVA was performed to see if there are fluctuations on levels of situational engagement across all measurement points. To know how much students' knowledge of science changed based on the pre- and post-knowledge tests, Paired comparison was used to compare the differences and similarities. Lastly, to identify possible differences between groups, participants were divided according to gender and grade. To test if there was any difference between males and females for reported level of self-efficacy, science attitude and performance (based on knowledge), a series of Independent Sample T-tests (two-tailed) were conducted to compare gender and grade differences on those variables. In addition, effect size (Cohen's d) for each test was calculated (no effect at $d < 0.2$; small effect at $0.2 \leq d < 0.5$; moderate effect at $0.5 \leq d < 0.8$; and large effect at $d \geq 0.8$) (Cohen, 1988). The effect is of such great importance as Cohen (1990) put it: 'the primary product of a research inquiry is one or more measures of effect size, not P values.' Effect size can be computed direct from the value of t, in the same way as doing an independent t-test (Rosenthal,1986).

As depicted in earlier sections, situational engagement was measured by an approach similar to ESM. In order to be situationally engaged, students need to report a higher-than-average level of situational interest, skills and challenge. Thus, the first step of analysis the ESM data is to convert the variable situational engagement into a dichotomous one, where a 0 means situationally disengaged, and 1 stands for situationally engaged. Since situational engagement was measured six times, the next step was to calculate the overall times of students being situationally engaged. As a result, a normal variable situational engagement was created, ranging from 0 to 6 (being situationally engaged for 0 to 6 times). Therefore, situational engagement as a variable in this study represents the overall times that students reported being engaged, based on three preconditions: situational interest, skills, and challenge. All three preconditions were measured with a five-point Likert scale questionnaire. Table 4-6 illustrates the analysis methods applied to each block of research questions.

4.5.4 Analysis of interview data

The use of qualitative data was an important part of this research, and as in the quantitative data, students were asked general subjective questions such as enjoyment of science, confidence of doing a science task. But it is also important to know the course features that they regarded as engaging in online learning environment. In this study, analysis of interview data applied a hybrid process of inductive and deductive thematic analysis, with the focus on inductive approach, as proposed by Fereday and Muir-Cochrane (2006). In addition, this study also referred to the work by Thomas (2006). This analysis approach integrated the merit of data-driven and theory-driven themes based on flow theory and engagement. Thematic analysis is an analysis that seek for patterns across qualitative datasets. The process of thematic analysis involves pattern identification, with researchers "carefully reading and re-reading of the data" (Rice & Ezzy, 1999, p. 258). Then those identified patterns or themes become categories for analysis. Interview texts enable researchers to conduct in-depth investigations of participants' experience and emotional and cognitive engagement in the MOOC, which contribute to the understanding of situational engagement and its associated factors.

There are several approaches for thematic analysis: there are data-driven inductive approaches or research questions/framework driven deductive approaches. But there are also hybrid approaches in which both inductive and deductive methods were applied in qualitative data analysis (Fereday & Muir-Cochrane, 2006). The merit of this approach involves a process that allows the integration of social phenomenology and deductive thematic analysis, and meanwhile allows the formation of themes/patterns directly from dataset using inductive coding. Neuendorf (2016) proposed a nine-step process of content analysis research, including theory and rational conceptualization decisions; operationalization measures; coding schemes (computer/human); sampling; training and pilot test reliability; final reliability; and tabulation and reporting. However, in this study, a structure using six components was chosen: theory-variables and conceptualization-human coding-reliability-reporting. The interview texts were inductively analysed using inductively generated codes guided by the research questions, the conceptual framework, the authors' prior knowledge, and even inferences from the dataset.

The inductive approach, also referred to as a data-driven or text-driven approach (Krippendorff, 2013). According to Thomas (2006), inductive analysis is an approach that converts raw data (e.g., text, video and audio) into formatted catalogues, themes or frameworks using careful and detailed reading techniques. It is a search for patterns, and researchers seek for similarities and differences in the raw data and make interpretations based on summary. In inductive analysis, the researcher moves from the data to a theoretical understanding–from the concrete and specific to the abstract and general (Graneheim et al., 2017). However, it is more likely to be a data-driven approach than a question-driven approach as opposed to a deductive analysis (Schreier, 2012). When compared with other approaches to qualitative data analysis, inductive analysis is less complicated, and it provides straightforward and easy approaches for extracting summaries from qualitative raw datasets (Thomas, 2006). There are challenges for conducting inductive analysis, but one is how to avoid surface descriptions and general summaries.

Following Thomas (2006), our reasons for applying an inductive analysis approach is simply to:

- convert the raw interview data into a formatted summary
- seek links between research questions/objectives and summary findings, and
- format a framework that underlies the experience of students' online engagement and factors

Based on the summary of earlier good practice, in this study, the following procedure was applied:

The coding work was done by two researchers (A and B) for the propose of ensuring inter-rater reliability. First, the interview text was read and studied holistically several times, preliminary notes and marks were made during the reading to form themes. A rigorous and systematic reading and coding of the transcripts allowed major themes to emerge. In particular, the interview text was read by A, and a subsample was read by B. First both A and B coded independently, and then together so the differences and similarities regarding codes were compared and sorted into tentative sub-themes. After a discussion, a coding/themes frame was agreed on and developed together, enabling an analysis of interview segments on a theme. In this process, once new themes emerged, both A and B re-read the interview transcripts and change the coding frame accordingly. This preliminary coding and discussion between two raters resulted a final set of codes.

Towards the end of the study, no new themes were emerging, which means all the important themes had been identified. Next, all the identified themes were discussed and grouped, to form catalogues. Several factors related to online learning engagement and students' overall experience of MOOC were identified. Links between those themes and catalogues were also explored based on the research questions and research framework. All in all, 15 themes were identified and based on which, four catalogues were developed. The Cohen's kappa which shows the degree of unanimity between coders, was .83, which is good if greater than .61 (Drisko & Maschi, 2015). Inter-rater consistency of .61 is regarded as acceptable while greater than .81 is treated as strong.

For example, one of the themes is "*general interest in science as manifested in daily life*". It was developed based on quotations such as:

- "Yeah, it's an English channel...and everything about black holes, or the world in general, and medicine, as such. Very intensive, the one makes lot of physics video...quite interesting."
- "I think I have similar experiences, even though I am not too good, I just watch them from time to time, because they are really, really interesting."
- "Yeah, it talks about some animals which are not common in Finland. Like, for example, (they) focus on a certain type of animal, also are extra interesting, we watched them as a kid, it was really fascinating.

Results of the study have been presented in the next chapter in accordance with the research questions and hypotheses. Sections 5.1 to 5.3 seek to answer research questions related to quantitative survey data, while in section 5.4, qualitative data were used as the main evidence, answering questions related to the students' general experience of the short course (RQ4). The combination of both data sources provides an overarching picture of situational engagement in online science learning and the associated factors.

5 RESULTS

The results were organized and presented according to the research questions and hypotheses. It is worth noting that quantitative analysis results for research questions RQ1, RQ2, & RQ3 were presented first. The content analysis on interview data were presented next, corresponding to RQ4. More specifically, results were presented based on individual hypotheses. Thus, this section is presented in a research questions-hypothesis-results structure.

5.1 If self-efficacy, feeling-related interest, and value-related interest positive predictors of students' online learning situational engagement

Table 5-1. Means, Standard Deviations, and Correlations of variables (N=193)

Variable	1	2	3	4	5	6
1. Situational engagement	---					
2. Feeling-related interest	.224**	---				
3. Value-related interest	.282**	.807**	---			
4. Self-efficacy	.294**	.501**	.547**	---		
5. Pre-Knowledge	-.077	-.159*	-.229**	-.103	---	
6. Post-knowledge	-.173	-.193**	-.195**	-.232**	.534**	---
Mean	1.306	4.147	4.300	14.93	1.80	2.03
SD	1.73	1.319	1.189	4.456	.835	.822

Note: Pearson's two-tailed correction was applied as Engagement are based on category variables. *p < .05. or Correlation is significant at the 0.05 level (2-tailed). ＊＊ p < .01. or Correlation is significant at the 0.01 level (2-tailed).

Correlations between all the variables studied were computed first to have a general idea about interrelationships. Table 5-1 shows the Means, Standard Deviations (SD), and Pearson' correlations among all studied factors. First, students' self-reported level of situational engagement was positively correlated with self-efficacy (SE) ($r = .29$, $p < .001$), feeling-related- and value-related interest in science ($r = .28$, $p < .01$; $r = .29$, $p < .01$ separately). Secondly, feeling-related interest was positively connected with value-related interest ($r = .81$, $p < .01$) and efficacy ($r = .50$, $p < .01$), but negatively related to pre- and post-knowledge tests ($r = -.16$, $p < .05$; $r = -.19$, $p < .01$); Similarly, value-related interest was positively linked to self-efficacy ($r = .55$, $p < .01$), but negatively related to pre- and post-knowledge test ($r = -.23$, $p < .01$; $r = -.20$, $p < .01$). In addition, although self-efficacy was negatively correlated with post-knowledge test, no such correlation was found between self-efficacy and pre-knowledge test. Finally, a significant interaction was also found between the pre-and post-science knowledge test ($r = .53$, $p < .01$).

Correlation does not mean causation. To examine whether self-efficacy, feeling-related and value-related interest are positive predictors of situational engagement (hypothesis H1a), a hierarchal regression analysis was performed. Hierarchical regression analysis was conducted using self-efficacy, feeling-related and value-related interest as independent variables (IVs), while the level of situational engagement was treated as the dependent variable (DV). Preliminary tests reported no violation of the assumptions of normality, multi-collinearity, linearity, and homoscedasticity.

H1a students' self-efficacy about science is a positive predictor situational engagement of online science learning (ACCEPTED).

Variable self-efficacy entered into the equation of step one, to estimate how much of the variance of situational engagement could be explained. Similarly, in step two and step three, value-related interest and feeling-related interest were entered accordingly. The force enter method was used so that all independent variables are entered into the equation in following steps. A significant regression equation was found $F (1,191) = 18.07$, $p < .001$, with an R^2 of .09. Which indicated that nine percent of the variance of situational engagement can be explained by variable self-efficacy. Although an R-squared figure of .09 is relatively low in regression analysis, it has been stated that in the social sciences it is common to have a small yet significant R-squared (Minitab Blog, 2013), or in some fields of study to have an inherently greater amount of unexplainable variation (Frost, 2018). Thus, a lower R-squared does always means bad models. Based on the results, the hypothesis 1a was accepted.

H1b students' value-related interest in science is a positive predictor of situational engagement in online science learning (ACCEPTED).

After step one, with value-related interest added into the equation, $R^2 = .11$, $F (2,190) = 11.42$, $p < .05$. Specifically, students' self-efficacy and value-related interest in science positively predicted their situational engagement (SENG) in MOOC learning environment. Thus, the addition of variable value-related interest resulted in a 2% increment in the variance accounted for. Accordingly, hypothesis 1b was also accepted.

H1c students' feeling-related interest in science is positive predictor of situational engagement in online science learning (REJECTED).

In step three, however, when feeling-related interest was included in the model, the result indicated that it did not significantly predict the overall level of situational engagement, with ($R^2 = .12$, $F (3,189) = 7.62$, ns). Therefore, despite a strong correlation being found between situational engagement and feeling-related interest, the latter variable failed to predict the level of situational engagement in MOOC learning. Accordingly, the hypothesis 1c was rejected. Table 5-2 shows the data corresponding to the regression analyses.

Collectively, the hypothesis 1a "Students' self-efficacy about science is a positive predictor of situational engagement in online science learning" was accepted. The hypothesis 1b "Students' value-related interest in science is a positive predictor of situational engagement online science learning" was also accepted. However, the hypothesis 1c "Students' feeling-related interest in science is a positive predictor of situational engagement in online science learning" was rejected.

Table 5-2. Hierarchal regression of science efficacy, value-related interest, and feeling-related interest (IVs) on level of situational engagement (DV)

Variable	B	SE B	ß (95% CI)	ΔR^2
Step 1				.09
Self-efficacy	.11	.03	.29** (.06/.16)	
Step 2				.01
Self-efficacy	.07	.03	.20* (.01/.13)	
Value-related interest	.25	.12	.17* (.02/.49)	
Step 3				.01
Self-efficacy	.08	.03	.20* (.02/.14)	
Value-related interest	.30	.18	.21 (-.05/.65)	
Feeling-related interest	-.06	.15	-.04 (-.36/.25)	

Note: N = 193; *p < .05, **p < .01, ***p< .001

5.2 Students' situational engagement was different across all the measures and contexts

H2a. Students' level of situational engagement was significantly different across all measures (ACCEPTED).

To examine the H2a hypothesis, one-way repeated ANOVA was conducted to see if the level of situational engagement across six measures was significantly different. Time (6 times overall) was used as the independent variable, while six-time situational engagement levels were treated as dependent variable. The results revealed that the effect of time was significant on level of situational engagement across the six-time measures. The result of the ANOVA indicated a significant time effect, Wilks' lambda = .829, $F(5, 187) = 7.71$, $p = .000$, $\eta p^2 = .17$, which revealed that the level of situational engagement was different across all the measures. Thus, the hypothesis H2a was accepted.

H2b. Students were more likely to be situationally engaged in content that related to their daily life (i.e., contextualizing - Connect energy consumption to the Finnish context), compared with the rest of situations (REJECTED).

In Section 4.4.1), it was already introduced that the six situational topics (or context) within the six probes were classified into three catalogues: SENG1: Explaining a concept/model (probe1&5); SENG2: Contextualizing (probe2&3); SENG3: Making a summary (probe4&6). Next the three catalogues related with topics in various situations were examined. The purpose was to know what contexts or situations are more engaging to MOOC learning students. Frequency of being engaged in each situation were firstly calculated separately, and means were calculated for each situation. In addition, means and standard deviations of engagement properties were also calculated to compare how they were different across different situations. According to the result, it seems that students engaged the best (at 23.85 %) when teachers explained a concept or model in detail (SENG1) and showed a slightly higher level of interest (M=3.09, SD=.94) than situations when teachers summarized the course content (22.3%) (M=3.07, SD=.94). Surprisingly, the course content dealing with energy statistics (SENG2, *contextualizing*) engaged students the least, with only 18.9% being engaged, and reported lowest level of interest (M=3.03, SD=.94), compared with other situations. Accordingly, the hypothesis 2b was rejected. Detailed explanation of the rejected hypothesis was depicted in section 5-3.

Table 5-3. Frequency of situ-engaged across three situations among participants

Contexts	**Situ-engaged (%)**	**Interest (M, SD)**	**Skill (M, SD)**	**Challenge (M, SD)**
SENG1 (Explaining concepts)	**23.85**	3.09 (0.94)	3.16 (0.70)	2.40 (0.78)
SENG2 (Contextualizing)	**18.90**	3.03 (0.94)	3.19 (0.74)	2.38 (0.79)
SENG3 (Making summary)	**22.30**	3.07 (0.94)	3.14 (0.72)	2.43 (0.81)

Note: as stated in methodology section, three situations representing six-time measurements, thus each situation was measured twice.

To sum up, the hypothesis 2a "*There is significant time effect on students' level of situational engagement (across all measures)*" was accepted, as a significantly different level of situational engagement was captured across the six measurement points; whilst the hypothesis 2b "Students were more likely to be situationally engaged in content that related to their daily life (i.e., statistics of energy-consumption), compared with the rest of situations" was rejected. This is because the result revealed that students situationally engaged more with sections on model/concept explanation, not the sections with the teacher using a contextualized learning approach which uses examples such as energy consumption in Finland.

5.3 Individual differences between secondary school students in science learning situational engagement

To compare individual differences and similarities, first, overall engagement times were calculated according to criteria for determining engagement, as one important aspect is to compare whether differences existed between students' total engagement times and across three situations. Another interest in this section was to compare engagement related factors) regarding gender and grade. A simple question was asked: Is the situational engagement level distributed equally across six times and does gender or grade play any role here?

H3a1 Boys report higher level of self-efficacy than girls (ACCEPTED).

The difference between male (M=16.30, SD=4.20) and female (M=13.53, SD=4.70) students was found to be significant on self-efficacy; t (191) = 4.32, $p < .001$, the effect of gender on students' self-efficacy was moderate to large (d=0.62). The result also indicated that, on average, male students were 2.77 times higher than girls in science self-efficacy.

H3a2 Boys report stronger feeling-related interest than girls in science online learning (REJECTED).

No significant difference between males and females was found in feeling-related interest (t (179.16) = 1.11, p = 0.27). The effect size of gender on feeling-related interest was trivial at .16. Thus, I rejected the hypothesis that the feeling-related interest in science is positively related to situational engagement.

H3a3 Boys report stronger value-related interest than girls in science online learning (ACCEPTED).

For value-related interest in science, although the p value was not significant, according to the result, as t (191) = 1.79, p = 0.08, but the Cohen's d for the variable value, related interest was small to medium at .26, thus this study conclude that the significant difference exists. Therefore, the hypothesis 3a3 was accepted.

H3a4 Girls report performing better than boys in science online learning in terms of knowledge tests (pre & post) (REJECTED).

According to the analysis, neither pre-test of science knowledge (t_{pre} (191.67) = -0.88, p =0.38) nor post-test knowledge (t_{post} (191.67) = -0.27, p =0.78) was significantly different between boys and girls. The effect size of gender on pre-knowledge test was very trivial at .12, and on post knowledge test it was .04. Collectively, I rejected the hypothesis H3a4. Table 5-4 summarize the output of gender differences.

Table 5-4 gender difference on self-efficacy, personal interest, and knowledge

Situations	Mean (SD)		t	P	*d*
	Males	Female			
Self-efficacy	16.31 (4.20)	13.53 (4.70)	4.32	**0.00****	**0.62**
Feeling-related interest	4.25 (1.14)	4.04 (1.47)	1.11	0.27	0.16
Value-related interest	4.45 (1.06)	4.15 (1.28)	1.79	0.08	0.**26**
Pre-knowledge	1.75 (0.81)	1.85 (0.87)	-0.88	0.38	0.12
Post-knowledge	2.02 (0.83)	2.05 (0.81)	-0.27	0.78	0.04

Note: *p < .05. or Correlation is significant at the 0.05 level (2-tailed). ** p < .01. or Correlation is significant at the 0.01 level (2-tailed).

Among all the factors, differences between male (M=16.30, SD=4.20) and female (M=13.53, SD=4.70) students was found to be significant on self-efficacy; t (191) = 4.32, $p < .001$; the effect of gender on students' self-efficacy was moderate (d=0.62). However, no significant difference between males and females was found in either science knowledge (t_{pre} (191.67) = -0.88, p =0.38; t_{post} (191.67) = -0.27, p =0.78) or feeling-related interest (t (179.16) = 1.11, p = 0.27). For value-related interest in science, although p value is not significant, (t (191) = 1.79, p = 0.08), the Cohen's d for the variable value-related interest was small at .26, thus this study conclude that the significant difference exist. The effect size of gender on feeling-related interest was trivial at .16; on pre-knowledge test was only .12, and on post-knowledge test was .04. Collectively, the hypothesis H3a was partially accepted (for a summary of all hypotheses, see Table 5-6).

H3b Boys are more likely to be situationally engaged than girls across all measures (ACCEPTED).

Table 5-5. Repeated measures of time and gender effect on situational engagement

Effect	*MS*	*df*	*F*	*p*	Greenhouse-Geisser	Huynh-Feldt
Time	1.490	4.56	8.76	< .001	< .001	< .001
Time x Gender	.10	4.56	.58	NS	NS	NS
Error	.17	870.17				

Note: "NS" means not significant.

A one-way repeated measured analysis of variance (ANOVA) was conducted to evaluate the hypothesis that there is a significant difference in participants' reported time of situational engagement across timelines, and there is also gender difference across the timeline on the level of situational engagement (N=193). Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $\chi^2(14) = 45.492$, $p < .0005$, and therefore, a Greenhouse-Geisser correction was used. A Greenhouse-Geisser correction determined that the mean level of situational engagement differed statistically significantly between time points, F (4.56, 870.17) = 8.763, P < 0.001. The results revealed that while there is significant main effect of time on the level of situational engagement across all measures, gender failed to play a role in affecting the participants' level of situational engagement across six times, F (4.56, 870.93) = .58, p = .74). In general, the mean score differences for situational engagement were significant across all times. The descriptive statistics revealed that males' (M=.42) mean time of being situationally engaged were slightly higher compared to that of females' (M=.32), the ANOVA revealed that this difference was significant F (1,3.4) = 5.83, $p < .05$. Thus, the hypothesis was accepted. To show how female and male students differed on situational engagement on all measurement points, Figure 5-1 was created, describing how the level of situational engagement changed.

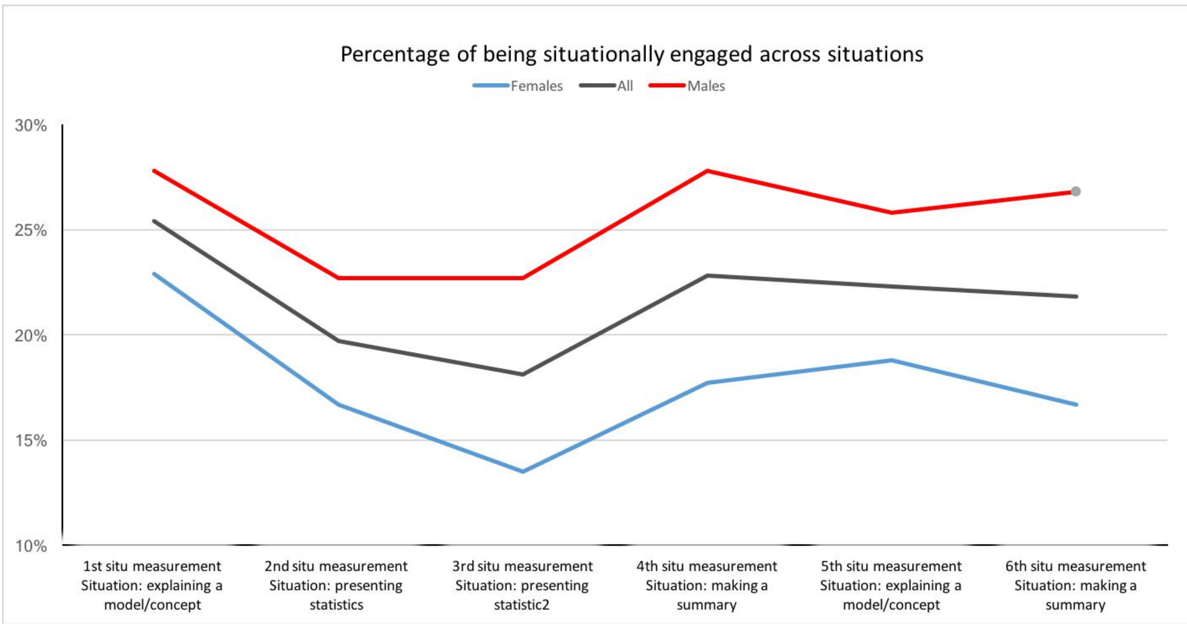

Figure 5-1. Situational engagement based on timeline and context

H3c1 Lower secondary school students report higher level of self-efficacy than upper secondary school students (ACCEPTED).

For factors associated with situational engagement, significant differences were demonstrated between lower and upper secondary school students on variable self-efficacy, t (191) = 3.34, p < 0.01. The Cohen's d was medium to large at .64, thus providing strong evidence for the existence of grade differences on self-efficacy.

H3c2 Lower secondary school students report stronger feeling-related interest than upper secondary school students in science online learning (REJECTED).

No obvious differences were found between lower and upper secondary school students on variable feeling-related interest, as t (123.33) = 1.32, p = 0.19. Despite a near-to-small effect size (d=.19), the hypothesis H3c2 was rejected.

H3c3 Lower secondary school students report stronger value-related interest than upper secondary school students in science online learning (ACCEPTED).

In addition, despite the differences between lower (M=4.35, SD=1.31) and upper secondary school students (lower (M=4.12, SD=.51) on value-related interest was not significant, (t (163.53) = 1.75, p =0.08), but there was a small effect size of .23. Therefore, in this study the hypothesis was accepted.

H3c4 Upper secondary school students performed better than lower secondary school students in science online learning in terms of knowledge test (pre & post) (ACCEPTED).

In addition, there was a significant difference between students of two levels on both pre (t (90.86) = -4.10, p < .0.001) and post knowledge t (191) = -3.97, p < 0.001. This effect on pre-knowledge was medium at .64, and medium to large on post-knowledge at .76. thus collectively, the hypothesis H3c4 was accepted in this study.

Table 5-6. Grade differences on self-efficacy, personal interest, and science knowledge

Situations	Mean (SD)		t	p	*d*
	Lower Sec.	Upper Sec.			
Self-efficacy	15.48(0.76)	12.80(3.59)	3.34	**0.00****	**0.64**
Feeling-related interest	4.19 (1.43)	3.97 (0.74)	1.32	0.19	0.19
Value-related interest	4.35 (1.31)	4.12 (0.51)	1.75	0.08	0.23
Pre-knowledge	1.70 (0.87)	2.17 (0.58)	-4.10	**0.00****	**0.64**
Post-knowledge	1.92 (0.83)	2.48 (0.64)	-3.97	**0.00****	**0.76**

Note: *p < .05. or Correlation is significant at the 0.05 level (2-tailed). ＊＊ p < .01. or Correlation is significant at the 0.01 level (2-tailed).

H3d Lower secondary school students are more situationally engaged than upper secondary school students in online science learning (REJECTED).

Likewise, a one-way repeated ANOVA analysis was conducted to explore if there was any difference between lower secondary school students and upper secondary school students across six measurement plots. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $\chi^2(14) = 42.876$, $p < .0005$, and again, a Greenhouse-Geisser correction was used. A Greenhouse-Geisser correction determined that the main effect of time on situational engagement was statistically significant, $F (4.589, 876.54) = 12.728$, $P < 0.001$. In addition, the interaction of time and grade was also significant on participants' level of situational engagement across six times, as the results showed: $F (4.589, 876.54) = 4.142$, $p < .001$. However, a closer look at the pairwise comparison revealed that lower secondary school students’ (M=.38) mean level of being situationally engaged were only slightly higher compared to that of higher school students (M=.34), but the ANOVA shown that this difference was not significant ($F (1, 191) = .55$, $p = .460$).

Table 5-7. Repeated measures of time and grade on situational engagement (across 6-time)

Effect	*MS*	*df*	*F*	*p*	Greenhouse-Geisser	Huynh-Feldt
Time	2.11	4.59	12.73	< .001	< .001	< .001
Time x grade	.69	4.59	4.14	< .001	< .01	< .01
Error	.17	876.54				

Taken together, as a result, the hypothesis 3a “There is significant gender difference in factors related to situational engagement" was partially accepted, as the only significant difference of gender on self-efficacy was found, not on variables such as attitude and science knowledge test. Meanwhile, the hypothesis 3b "There is significant gender difference across all the measures of situational engagement" was accepted as a clear difference was found on gender across the time points. In addition, although significant differences of self-efficacy and science knowledge were found in students at lower and upper secondary school level, no such difference was found on grade in terms of situational engagement. As a result, the hypothesis 3c "There is significant grade difference in factors related to situational engagement" was accepted, and the hypothesis 3d "There is significant grade difference across the all measures of situational engagement" was rejected.

5.4 The factors of online learning engagement that students reported: Case illustration

The purpose of having qualitative data is to explore more aspects of students' engagement in science learning, in a general way. In addition to motivational factors such as interest and attitude, it was found that the degree of autonomy as perceived by students is also important. In addition, the quality of course, including the quality of subtitles, sound effects and issues like video production methods were all mentioned in the interview. Some of those factors were corresponding to the survey data, adding more evidence to findings from quantitative data. Each part of the factors has been summarized and presented below.

Interest as a precondition

Students' interest here refers to the level of interestingness of either the science topic or the subject as a whole. For most students, interest seems to be the most important factor in science engagement. It refers to courses being "interesting", teachers and teaching style being 'interesting' or students themselves being interested in this subject. For example, students mentioned in the interview that:

> *It's really important that, like if a person is talking something not interesting, then you are not interested at all...when a person who likes biology talks about math, it's not interesting... (when) it's super enthusiastic, the student learns so much... it was the most boring... but she made the lesson so entertaining, funny...we missed the class for school party or (activities). (P.09)*

Even when asked about their out of school science activities, most of the students expressed their science related hobbies as generally 'interesting' and fun. Being interesting seems to be the pre-conditions of their science learning engagement. For example, one interviewee talked about his extracurricular activity of leaning more science being to follow some YouTube channels and watching YouTube videos, which he described it as very interesting and 'intensive'.

> *'Yeah ... it's an Englis channel...and everything about black holes, or the world in general, and, medicine, as such. Very intensive, the one makes lot of physics video...quite interesting.' (P.04)*

A certain degree of autonomy

According to the semi-structured interview, it seems that learning autonomy, or put it simply, that students have choices when conducting a learning task is very important for their motivation for learning and engagement in situations. Secondary school students wish to have control over what to learn and how to process their own study. In most cases, learning autonomy was an important factor for self-directed learning and online learning. Secondary students' desire for freedom in study was also underlined in their interview. For example, one upper secondary participant expressed his opinions:

> *'Yeah we just like to progress ourselves, and we do anything else, even it will be educating ourselves with something completely different...maybe the best part for those videos, those science videos, that, you watch them in your free time, you know you don't have to make a project out of it...like if somebody force me to go, it would not be same if I go there myself, on my own way. Hmm, own choices...' (P.05)*

For learning materials such as a MOOC, students need to have a certain degree of autonomy, such as how and when the task should be finished. This offers them more choices in terms of tasks and course topics, than they can choose based on interest and level of competence. However, for secondary school students, too much autonomy may not always be a good idea. In the interview, there are critical voices on issuing too much autonomy for school study. For instance, some students do not think the idea of having too much self-paced learning is that good, if one lacks a proper time-management skill, self-paced study may lead to a totally different result.

> *'To focus on this topic, we have to do it ourselves, and you know what happens when you do it yourselves...Your progress is totally different...' (P.05).*

There have been long debates regard the important role of autonomy on learning engagement, both in traditional classroom and in web-based learning environments. Autonomy as one of the motivational antecedents of engagement (Skinner et al., 2009) was discussed frequently in the literature under theories such as self-determination theory (Ryan & Deci, 2000). Teacher's autonomy supports and influences students' classroom engagement (Reeve et al., 2004), and specifically, autonomy support played an important role in enhancing pupils' emotional engagement (Hospel & Galand, 2016). Thus, attention should be paid to this aspect when designing learning materials or modules.

MOOC instructors and teaching style

The features of teachers are reported here as a necessary factor in students' learning engagement. Teaching style here refers to tone of speech (being monotonic or passionate) and speaking rate (i.e., faster or slower). In this study, the style of teachers was mainly depicted from the speech aspects. Based on the interview, it seems that students generally engaged more with courses featuring teachers that were passionate about what they were delivering, or (and) talking at a relatively fast speed. Below are several selected answers from the students:

"I watched the video with the lady in it…I felt like bored and voice wasn't that interesting…I mean the way they talk…like talk steady boring one. And the man was like, (a stop), much better…" (P.01)

"Like once we have one really "good" history teacher…a bit like mean teacher… there some jokes around school…she gives us a task to do with 10 minutes long video, we have 5 minutes for it…" (P.06)

"(Teachers are) extremely important… like we have the videos like there's only presentation and background voice…if you can sense that the person talking is really enthusiastic is much enjoyable than a person in monotonic voice." (P.06)

Talking fast in an online course, however, is not welcomed by everyone. One student told a story as follow:

"She's on the first slide of PowerPoint, then the student gets to sleep. Then like for 5 minutes, then we are at 15 (minutes), she's so fast… a bunch of students sitting there at the background, she's like, with pages that goes so fast, going, going, going…" (P.06)

Quality of learning materials

The learning materials in our case refers to the online course video, audio, subtitles, and quizzes. During the interview, secondary school students emphasized the importance of course quality from several aspects. First, video production preference, which means how the courses were produced. Although a study has been conducted in section 5.2 regarding the engagement level of students in two kinds of video, it failed to explore, for example, which video production method were mostly welcomed among students. According to the students, the most welcomed video production method was text shown on the screen with a background voice. Normally they do not like 'talking head' videos.

"I like courses with no person face, just content, and someone is talking in the background. You can focus on the content and not on the one who makes it. I remember some YouTube videos, like there's only the texts, or something like that, it also good way to do a video." (p.03)

"Well, I prefer only text with only background voice. Because I can see the points they are trying to make, I can look at them as soon as they talk about it, I can look at it and hear about it." (P.03)

Although all the interviewees agreed that plain text with a background voice make the perfect online learning video presentation style, some also mentioned that it depends on the purpose of the learning. For example, one student gives his opinion from the prospective of language learning.

"I think I like the background voice (style of video) … but then I think it's more difficult when the person is not speaking in Finnish, which is my mother language, so if it's in English, it's like sometimes more difficult to concentrate with …when it's

in English or some other language, I prefer watch someone there with talk (interview/conversation)." (P.03)

Lastly, to simplify the understanding of the results of this study, a summary table was created (Table 5-8). The table firstly lists the main research questions concerned, and then briefly presents the main results related to each question.

Table 5-8. Summary of study results based on individual hypotheses

Research questions	Main findings
RQ1 *How is secondary students' online learning situational engagement predicted by the factors of self-efficacy, feeling-related interest, and value-related interest?*	1. Both self-efficacy and value-related interest are positive predictors of MOOC learning situational engagement. 2. Feeling-related interest has no effect on level of situational engagement.
RQ2 *What influence do time and course contexts have on students' level of situational engagement in an online learning environment?*	1.Overall, students reported significantly different levels of situational engagement across all the six time periods. 2. Teacher explaining a concept/model seems to be most engaging situation to students.
RQ3 *What are the gender and grade differences in the lower and upper secondary schools in terms of student's reported situational engagement and related variables in a science MOOC environment?)*	1. In terms of gender, significant differences were found only on self-efficacy in favouring boys. 2. Grade-wise, significant differences were found on self-efficacy in favouring lower secondary school students, and on science knowledge in favouring upper secondary school students.
RQ4 *What are the aspects and themes that affect students' situational engagement in a science MOOC environment?*	Interest as a starting point; a certain degree of autonomy; teachers and teaching style; and quality learning materials are important factors for online learning situational engagement.

6 DISCUSSION

6.1 Main findings and their importance

Secondary school students' online leaning situational engagement and several factors associated with it were examined. Flow theory was applied, to understand and define situational engagement in this study. Overall, four blocks of research questions, and 15 hypotheses were investigated using a science MOOC on the topic of sustainable development. In the first block of questions, attention was given to interrelationships between the factors studied and the effect of students' self-efficacy, feeling and value-related interest in science on reported levels of situational engagement. In the second block of questions, the effect of time and contexts of the course on students' reported level of situational engagement were examined. Situational engagement is the core concept of this study. Overall, this study applied a six-time-ESM-measure of situational engagement. Those six-time ESM measurements represent three catalogues of course contexts (or situations). Situational engagement was compared across different situations. The third block of questions sought to examine individual differences of students' science MOOC learning, through which gender and grade differences and similarities were tested. Lastly, one block of questions was asked about perspectives of students' experience of a science MOOC, based on the interview data. The main findings were described according to the order of the research questions.

6.1.1 Does a higher level of confidence and personal interest mean more situational engagement?

Motivational factors such as self-efficacy, interest were positively correlated with science achievement (Lavonen & Laaksonen, 2009) and science engagement (e.g., Ouweneel et al., 2013; Shea & Bidjerano, 2010). Although such motivational factors have been intensively studied across many subjects (i.e., science, mathematics, readings), less effort has been made to investigate the interrelationships between situational engagement, motivations, learning achievement in online science learning settings. A closer look at such relationships adds knowledge to people's understanding of situational engagement and how motivation plays a role in it. In this study, we tested several factors associated with situational engagement. There are more motivational factors such as general self-efficacy, personal interest in science (including feeling-related interest and value-related interest), and science performance.

In this study I found that students' self-efficacy about science are positively related to situational engagement in online science learning. This means that students with higher levels of confidence are more likely to be engaged in a learning task. Self-efficacy was also positively associated with both students' feeling-related interest and value-related interest in science. In addition, students' feeling- and value-related interest was also positively associated with level of situational engagement in online science learning. Further regression analysis revealed that both students' confidence level (self-efficacy) and value-related (personal) interest were positive predictors of their reported level of situational engagement. Self-efficacy is the strongest predictor, it alone explained 9% of the total variance of situational engagement. Interestingly, learners' perceived level of enjoyment of doing science (feeling-related interest) failed to predict such engagement in some situations. Therefore, it seems that students with a higher level of confidence, degree of enjoyment and who placed a strong personal value in science subjects are more likely to be situationally engaged during a short science learning task. This result is consistent with current knowledge of science engagement in classroom settings, as in most cases, motivation, engagement, and learning achievement are found highly related (i.e., Bresó et al., 2011; Uçar & Sungur, 2017).

Self-efficacy in this study referred to secondary school students' beliefs about their knowledge and skills to master an online science course. According to Bandura (1994), self-efficacy beliefs shape how one feels, thinks, and behaves. People with a strong sense of efficacy tend to have better accomplishment and enhanced personal well-being. In online learning settings, such self-efficacy is even more important. Pupils who were highly confident in their capabilities to master the course content were more likely to invest more energy and time, regardless of the difficulties (Bates & Khasawneh, 2007). Such an efficacious outlook strengthens intrinsic interest and promotes deep engagement in a learning task (i.e., MOOC learning). When equipped with such self-efficacy, pupils set themselves challenging goals and maintain strong commitment to them. That also explained why self-efficacy was a positive predictor of situational engagement. From a previous study, it was already known that students' self-efficacy was positively linked to each aspects of learning engagement (Uçar & Sungur, 2017). Students with high self-efficacy tend to study hard, invest a lot of effort and energy, and to carry on in the face of difficulties. An online learning environment such as a MOOC requires a higher level of self-efficacy from students, as learning can take place more independently, and be demanding in terms of perseverance and energy. Thus, for the purpose of engaging more online learning students, it is suggested that researchers and educationists should work together and develop students' academic confidence (Usher & Pajares, 2008), a crucial aspect of which is academic self-efficacy. In teaching practice, for example in a science subject, teachers should pay attention to cultivating pupils' self-efficacy through various methods. First, for students in lower grades, setting learning tasks that are either too easy or too hard can foster mastery experiences. Secondly, setting social models for students, because seeing people similar to them succeed in science by sustained effort, may also raise their beliefs that they hold comparable abilities (in doing science). In addition, for online courses such as MOOCs, it is also important to expose the learners to authentic situations by creating conditions that they will encounter in real life (for example, in science projects). Nevertheless, teachers should be aware of the source of self-efficacy and finding proper ways to design and deliver science courses. It is worth mentioning that though personal interest was investigated as a predictor of situational engagement, it was not discussed in this part. Interest related to online science learning is discussed separately in the next section (6.1.2).

6.1.2 Science learning: Personal interest (feeling and value-related) Vs. situational interest

Interest is a content-specific concept, and it is always associated with specific tasks, topics, or activities (Schiefele, 1991). The measurement of students' personal interest in science consisted of two parts that originally came from PISA test items (OECD,2006). One part deals with feeling-related interest, while the other is blocks of questions to measure value-related science interest. In the context of this study, feeling-related valences refer to students' feelings of enjoyment and involvement with an online science task, whilst value-related interest refers to how students related learning of science to personal significance (i.e., science helps understanding the world around).

It was assumed in this study that students who largely agree with enjoyment and value of science may also report a higher level of engagement in an online science learning activity. The hypothesis was partly accepted, as students with greater value-related interest were more likely to be situationally engaged in the science online learning environment. However, surprisingly, learners' degree of enjoyment (feeling-related interest) failed to predict level of situational engagement. Such a finding means that if students perceived the functionality, or usefulness of science as a subject, they are more likely to invest a greater degree of energy and time in studying science. This tends to be true even in a short task. But the perceived the pleasure of learning science did not contribute to their active learning involvement. It may be the fact that there were no episodes which stimulated feeling-related valences of interest, and students have to take this online course, as it was a part of the school study programme. Thus, value-related valence of interest is more likely to predict situational engagement when students related school science study to their future or see the potential of science in improving the world. According to Schiefele (1991), subject-matter-specific interest (e.g., environmental science) is more vulnerable to instructional influence than that of general motivations or individual interest. A close look at the results of this study found that students reported a lower degree of enjoyment (also feeling-related interest) than that of personal value (or value related interest) ($M_{feeling}$= 4.1, M_{value}= 4.3). This difference, despite not being numerically significant, revealed that students cared more about how science related to their future, or on usefulness aspects of science, rather than how they enjoyed learning it. A similar trend has been observed in international assessment programmes such as PISA: There was a substantial decline in enjoyment of learning science among Finnish children (OECD, 2017). Taking the current situations into account, it is not surprising that in this study, feeling-related interest failed to predict science engagement in situations. It is arguable that secondary school students learned science mainly because of its usefulness, or personal significance, not simply for fun. Alternatively, they may put more emphasis on the future aspects or career aspirations, compared with simply happiness from learning it. More studies could be done to examine these questions. For example, future study could compare such dimensions of personal interest between primary school students and secondary school students.

What does this mean to science teaching? Current studies have found that as students grow up, their general interest in science decreases (Trumper, 2006). Thus, for secondary school students it is of great importance to make science both entertaining and useful for their future. Teachers should use well-selected course content that is attractive, interesting and related to their future in the workforce. Making students more engaged in learning science is a crucial step to keeping more young people in the STEM fields, a field that is shrinking.

This study of interrelations also took science performance into consideration. It was assumed that a higher level of situational engagement would correlate with better science performance (in this case: the post-knowledge test), however no clear link was found between situational engagement and performance. One possible explanation of such a rejected hypothesis would be the course characteristics itself: it is too short. Thus, such situational engagement can hardly affect students' level of performance in a relatively short course. For measuring academic performance, a longitude study design is preferred. Lastly, students with a higher level of self-efficacy and attitude tend to perform better in terms of the end-task knowledge test, compared with those who scored lower in self-efficacy and attitude to science. This is consistent with previous studies in the domain of STEM subjects such as science (Britner & Pajares, 2006; Kose et al., 2010), computer and engineering education (Compeau & Higgins, 1995; Thatcher & Perrewe, 2002), and in mathematics (Bates & Khasawneh, 2007; Shen et al., 2013).

6.1.3 The context-dependent feature of situational engagement

One of the biggest differences between memory-based engagement measurement and ESM measures is the time when such questions were presented. As depicted in earlier research (i.e., Schneider et al., 2016; Inkinen et al., 2019), situational engagement is normally measured multiple times during a learning task. Compared with the once-and-for-all approach (such as memory-based questionnaires), the ESM approach enabled me to know students' fluctuation, frustration, or even burnout in a learning session (Salmela-Aro et al., 2016). In other words, the time and the context of each measurement matters, since analysis of the effect of time and context of the course provide information on how learners fluctuated and what kind of context explained the fluctuations. During the past few years, it seems that engagement in situations is getting increasing attention among researchers: for example, in the field of medicine (i.e., Rotgans et al., 2018) and in science (Inkinen et al., 2019; Schneider et al., 2016). In addition, the context-specific feature of engagement was proposed, arguing that engagement is more or less dependent on the task at hand, as the task determines the extent to which students are willing to invest energy and time (Rotgans & Schmidt, 2011). For instance, in science classes, students' situational engagement may have differed according to scientific practices in designed science learning situations (Inkinen et al., 2020). Similarly, in an online course, different contexts of the course (e.g., knowledge, teaching style) may affect the reported level of situational engagement. It is important to know how and why different levels of situational engagement were reported. That is the goal of the second set of research questions.

As noted earlier, a central goal of this study is to figure out whether different contexts of the course (i.e., situations, time of measurements) lead to various levels of situational engagement. Based on Hidi and Renninger's (2006) classification of interest, students' interest in a science MOOC in this study was interpreted as situational interest, being either a triggered one or a maintained one, and the development of interest depends not only on the person but also on the environment and content. Under such definition, it was assumed in this study that students' engagement across several situations would vary across all the studied contexts and timelines. From the perspective of relativeness and self-determination theory (SDT) (Deci & Ryan, 2012), for this study it was assumed that data on everyday life that related to students would be more engaging than obscure concepts (or when a teacher explained a concept or a model). Results confirmed the hypothesis that situational engagement across all the six time points are significantly different, with a series of ups and downs, indicating a fluctuating process. However, results also showed that students seem engaged more with the context in which teachers were explaining a concept than sections which teachers were contextualizing, such as Finnish domestic energy consumption. Why? This can be interpreted via previous studies and theories on deep learning and surface learning. According to Williams (1992, p. 45), deep learning refers to learning with understanding, while surface learning refers to more temporary learning. Deep learning refers to learning with aims of understanding, such as understanding and critical thinking; testify of logic, or seek evidence, whilst the surface learning approach by students involves memorizing concepts or topic without giving a question, memorizing facts without distinguishing patterns and principles that related (Beattie et al., 1997). A deep approach to learning is characterized by both an interest in a subject and a personal commitment to a task (Hall et al., 2004). Therefore, in the sections with higher levels of engagement, teachers were giving thoughtful explanations of concepts such as 'sustainability' and examples were also presented. Students in this situation may apply a deeper approach, as it may be challenging to understand and require critical things to distinguish the logic of teachers' arguments. Instead, while dealing with sections for which only statistics were given, no such deep understanding of those were required as it only takes memory to keep it. Therefore, students were less likely to exert a deep learning approach to master that knowledge. As Beattie et al. (1997) argued, a surface approach to learning is more like rote learning, while a deep approach is a more conceptual form of learning. Despite the above arguments, perhaps statistics are not that interesting to students or simply they were not associated with daily life.

One conclusion can be based on such findings, that teachers should know students' engagement in MOOC learning is not a stable or once-for-all status. Instead, it is a process of constant change, depending on the contexts of teaching and knowledge. For teaching, such results suggest that more modules with science inquiry in classroom science teaching or in online learning should be used, which may promote deep learning. More importantly, due to the fragile feature of situational engagement, teachers should monitor the process of online learning and provide in-time feedback and interventions as needed. A recent study on how situational engagements were related to students' scientific activities also found Finnish students engaged more when working or using a model or constructing an explanation, compared with students in the U.S. (Inkinen et al., 2020). However, readers should be aware that this study compared engagement in different situations based on instructors' teaching activities, not on students' reported contexts.

6.1.4 Gender differences of situational engagement: Totally different or mostly similar

The third block of questions concerned individual differences. First, regarding gender differences, no significant difference was found between male and female students on the level of situational engagement across all situations. Environmental topics in Finland were found to be gender-neutral, based on an earlier traditional survey (Lavonen et al., 2005). In fact, the only significant difference found between boys and girls was on the self-efficacy of science. On average, boys were more academically confident than girls in the field of science study. However, no significant difference was found either on personal interest or on science performance. Secondly, on grade difference: First, no grade difference was demonstrated between lower secondary students and upper secondary students in Concept Explanation (SENG1), but lower secondary students are more likely to be engaged in the course section when statistics that related to the Finnish context (SENG2) were given or teachers were summarizing a section (SENG3), compared with their upper secondary counterparts. In terms of how grade can predict situational engagement, firstly, lower secondary school students reported a level of self-efficacy that was nearly three times higher than students from the upper secondary level. In contrast, as predicted, upper secondary school students tended to be good performers in terms of science knowledge, with slightly higher scores in the post knowledge tests. Interestingly, there was no significant difference between lower and upper secondary school students on factors such as attitudes to science, which referred to feelings and value-related interest in this study.

According to the analysis, though significant differences were found on prior knowledge between males and females, the effect size was trivial (.12 for pre knowledge; .04 for post-knowledge). Globally, a trend was observed during the passing years, that girls have reached parity with boys in performance in some STEM subjects, such as in science and in mathematics (Hyde & Linn, 2006; Hyde et al., 2008a). Such similarity has been testified in US as well as in several Asian countries and economies (i.e., Japan, Taiwan). According to international evaluation programmes such as PISA (2015), in Finland, girls scored more than 15 points more than boys in science performance, and Finland is the only country in which girls are more likely to be top performers than boys. But worldwide, such differences between females and males in performance were relatively small, at only 4 points. It was statistically significant, but numerically small.

However, no significant difference was revealed between females and males in the rest of the factors. For example, in self-efficacy, attitudes to science, a good explanation of the result could be the gender similarities hypothesis as proposed by Hyde (2005) early last decade. She did a systematic review of 46 meta-analyses on gender difference in the period from the 1990s. This review supported her hypothesis of gender similarities and argued that males and females are similar on most, if not all, psychological variables. Hyde also agreed that "of course the so-called gender difference can change substantially across ages and contexts of measurement” (Hyde, 2005, p.590). Specifically, she found that the gender differences in 78% of the data were very small or close to zero, a similar result as reported by Hyde and Plant (1995) one decade ago, when they found 60% of effect sizes for gender differences were in the small or close-to-zero range. Despite such claims, gender wise, students’ interest differed drastically in STEM related subjects. For example, in engineering, the difference is large, and it is moderate for interest in science (based on effect size). In this study, the effects size for gender on self-efficacy were medium to large (d= .62) on self-efficacy. In terms of personal interest, the effect of gender on feeling-related interest was trivial at .16 and small at .26 separately, both in favouring male students.

Although my findings are consistent with global trends, it is inconsistent with recent Finnish studies on environmental science. For instance, one study found that girls tend to report a significantly higher attitude about environmental responsibility, and also higher interest in environmental issues than their male counterparts (Uitto et al., 2011). There are reasons for that: firstly, although the topic of this study is sustainable development that is close to environmental science, the questionnaire items were more on general ‘hard’ aspects of science. Uitto and colleagues (2011) used questionnaires that were concerned more with the interaction between humans and the environment, or how personal level activities affect the bio-environment. Secondly, an earlier study has found that girls and boys differed across aspects of sciences. For instance, in terms of interest, Su and colleagues (2009) summarized the difference as “Men and Things, Women and People”, which they maintain that in domains such as science, women, in a general sense, were more interested in ‘human-aspects’ (closer to ‘soft’ science) and men more interested in ‘object-aspects’ of science (similar to the aforementioned ‘hard’ science). Therefore, it is arguable that such inconsistent findings are partly due to the use of different questions.

Although individual differences such as gender issues have been a hotly debated topic, especially on how women are underrepresented in STEM fields, globally, current studies also argue that gender differences cannot be over-emphasized, as it may disengage girls from entering STEM related fields (Blickenstaff, 2005). Another reason could be the fact that gender gaps seem to be decreasing gradually. Such decreases were manifested in the PISA results. For example, according to the PISA 2015 results, gender differences in students’ epistemic beliefs, despite being significant, were very small (OECD, 2015). Still, the gender differences existed. For instance, globally, in STEM subjects such as mathematics, girls and boys had similar level of performance, but their level of self-efficacy differed significantly in the favour of boys (Else-Quest et al., 2010). Motivational factors such as self-efficacy and attitude are important due to their power in shaping people’s decisions about whether to take on a challenging task (Hyde, 2014).

To neutralize traditional stereotypes on gender differences on performance and interest in subjects such as science, we need to increase our awareness of gender similarities. That said, it is agreed in this study that some research focus in gender difference can shift to the continuing work of proving gender similarities in many educational and psychological aspects, and how factors altogether contribute to students' wellbeing and epistemic development. As Hyde (2005, p. 590) put: "It is time to consider the costs of overinflated claims of gender differences. Arguably, they cause harm in numerous realms, including women's opportunities in the workplace... and communication, and analyses of self-esteem problems among adolescents. Most important, these claims are not consistent with the scientific data."

Lastly, research on gender differences and similarities is important for several reasons. First, currently many stereotypes of gender differences exist, and such bias affects people's behaviour, so it is important to test how accurate they are. Secondly, gender differences such as psychological gender differences are often invoked in important policy issues, and it was used to explaining certain social phenomenon, such as single-sex schooling (Hyde, 2014). Therefore, to evaluate policy recommendations and explanations, it is important to have accurate scientific proof on gender differences and similarities. While effort has been made in school science, it is also crucial to investigate such differences in online learning environments.

6.1.5 Factors that affect students' science learning situational engagement (evidence from the interview)

In addition to using the survey and ESM data, a semi-structured interview was conducted in this study, in order to identify more factors that students reported as important for engagement. A mixed method approach enables researchers to understand secondary school students' engagement explicitly. According to a literature review on online learning engagement, Yang and colleagues (2018) found a trend in the application of mixed methods in recent online learning engagement studies. Due to the flexibility of online learning and the complexity of learners online, there is no doubt that a mixed approach provides more research evidence.

In research question four, the study asked what are the factors that students reported that could affect their online learning engagement. Four themes emerged from the analysis of the interview text: interest as a precondition of engagement; the importance of having autonomy; the teacher and teaching styles; and the quality of learning materials. Interest and as one basic motivational factor for learning have been studied thoroughly and reported in the literature. In most cases, interest was one of the preconditions of starting an activity. A certain degree of autonomy promotes active engagement during an activity. Besides the motivation and perceived freedom, students generally engaged more with teachers who speak at a relatively faster speed and with passion, compared with teachers who talk at a slower speed and in a plain tone (See section 5.2). In addition, in this study, secondary school students preferred online courses with videos that had been made simply with PowerPoint and a background voice, instead of having the lecturer's 'talking head' presented on the screen. However, this result was inconsistent with current studies on video engagement. For example, according to the work of Guo and colleagues (2014), students engaged the most with "talking head" style videos. There may be two reasons for such inconstant findings. To begin, in the Guo study, they used a sample that consisted mainly of college students, but in the present study, participants were secondary school students. Therefore, the age difference may have played a role in video preference. Secondly, the studies applied different methods for measuring engagement. Guo and colleagues approached engagement by looking at how long students were watching each video, and whether they attempted to answer post-video assessment problems (Guo et al., 2014), and they therefore focused more on the aspect of video engagement than situational engagement. Future studies can confirm such research on learners' video preference at various educational levels, while applying the same measurement. Besides educational study, video engagement has been explored from other fields such as linguistics and computer science. Audience engagement or conversational engagement were also investigated by researchers, for example, from the perspective of eye gaze. One study found how gaze behaviour of individuals differ during distinct levels of conversational engagement (Bednarik et al., 2012). Since self-reported engagement data by students can be subjective, other approaches such as eye tracking techniques or using human observers may provide multiple layers of information for understanding engagement in different educational settings, or across various situations.

6.2 Contribution of this study

6.2.1 Situational engagement as a process

One of the important contributions of this study has been the view of situational engagement in an online learning environment. Instead of treating engagement as a once-and-for-all state (that is, the mainstream ideology), this study treated engagement as a dynamic process, arguing that the level of engagement may change in online learning environments based on specific contexts and situations. This study has shown that situational engagement is better interpreted as a process than a state, and time did play a role in the level of situational engagement (see Figure 5.1). Students' engagement in an online learning task indicated a process with 'ups and downs'; they engaged and disengaged in accordance with different situations that includes topics, style of teachers and learning environment. Through the repeated measures of perceived interest, competence and challenge during a task, it is possible to investigate which situations are more engaging for students, and why it is engaging. Compared with studies that measure engagement by the end of a task, treating engagement as a process enables teachers and course designer to understand students' performance during a learning task, thus providing useful information for both course design and educational intervention. See Figure 5.1 for a description of engagement process during the science task. As also depicted in the results section, it was obvious that the percentage of students being engaged was significantly different, both across all the time points, and between males and females, despite a similar pattern between genders being observed. Much detail would be lost if treating and measuring engagement occurred only once during a task, thus ignoring the learners' frustrations during an online task.

6.2.2 The effect of time and contexts (of MOOC) on situational engagement

Another possible contribution of this dissertation is its attempt to understand what happened during online learning across different contexts or situations. First, this study compared secondary school students' reported level of situational engagement based in three situations, or contexts of the course (See Figure 5.1 from section 5.3).

Compared with most previous work that measured engagement in a broader sense, it went deep into the contexts of knowledge within videos, to explain how different situations and how time affected students' reported level of situational engagement (or disengagement). Therefore, this study is one of the earliest to explore the micro level of situational engagement among secondary school students in a science-themed MOOC. This may add another layer of knowledge to current understandings of situational engagement. In addition, such effort helps course teachers to identify possible patterns of students' learning engagement and provide insights for further course improvement and conduct learning analytics within a typical learning group. Hopefully, there will be more academic interest in examining situational engagement across different domains and different aspects of engagement (i.e., cognitive, behavioural, and emotional engagement in situations).

6.3 Limitations of this study

There are limitations in all studies, and this one is no exception. Several facts need to be considered when interpreting the results of this thesis. First, the sample size. Readers should be aware that the sample size of both the surveys and the interview were relatively small (with 193 cases for the quantitative data, and five participants in a semi-structured interview). In addition, although the participants were recruited from three schools across two cities, the result cannot be generalized. A larger sample size would enable better statistical power and more reliable results. In addition, future study should include more samples representing a range of cultural backgrounds and regions. Secondly, there should be limited scale items. For measurement of students' online learning situational engagement, this study utilized a three-item questionnaire that was repeated six times during the course, an approach that is like the Experience Sample Method. Moreover, the measurement of students' personal interest in science consisted of only five items. The justification for doing so is that it is crucial to control the number of questionnaire items, in order not to disturb students' online learning flow, because of the complexity of online learning and multiple measurement of situational engagement. Nevertheless, the team set a standard that students should be able to complete each individual questionnaire within two to five minutes. Still, having limited numbers of items may lead to problems such as getting over-generalized results, misleading readers to some extent. Besides, it is also worth mentioning that while measuring students' situational engagement during a short course using pop-up questions was somehow an innovative approach, and an effort was made to minimize the number of question items, authors cannot control the negative impact of having too many measurement times appearing during a study. For example, the measurement of in-task situational engagement six times may have bored students. As a result, unreliable answers or missing data may have emerged. For such studies, a minor compensation could make the participation more active, as recommended by Fredricks and McColskey (2012). In addition, there are limitations in the ESM data analysis. For instance, when investigating which context of MOOC may be more situationally engaging, only percentages of students being engaged in all situations were calculated and compared, due to the feature of the data and the purpose of research, maybe more sophisticated methods of analysis could be applied. Developing better ways of analysing ESM data would be crucial in future studies.

One more limitation is the language used for the semi-structured interview. Even though interviewees in this study spoke good English, it is also important to note that English is not their native language. Rather, Finnish is their mother language. The interview was conducted in English because the English language is easier for me. For secondary school students, conducting an interview in their native language might be more productive and enable students to express themselves more naturally and discuss topics more in-depth. Therefore, the interview language may affect the quality of the data collection. To avoid this problem, future studies should consider conducting interviews using the participants' native language. Lastly, there is a limitation regarding analysis of the qualitative data. Because of the nature of a doctoral study, the interview data in this study were analysed mainly by the author (although another researcher participated in the coding process), which means most of the codes and themes were developed by the doctoral student, then discussed with the supervisor. Such practices and processes are good for consistency in the method but they failed to provide multiple perspectives from a variety of people.

6.4 Notes for further study

Not every study is perfect, and what is lacking in the current study will push me to do better in future projects. In this section, suggestions for future study were provided not only based on the limitations of this study, but also on the state-of-the-art technologies and methodologies for measuring engagement. The focus of such discussion here will be the measurement of engagement in situations.

6.4.1 Learning personas: identify learning patterns

Though this study managed to measure several situational engagement and factors that may be associated with it, revealing the importance of contextual influence on students' level of engagement, it failed to go further on issues such as identifying learner types or patterns of engagement. They are also important topics since patterns of engagement provide detailed information for creating learner personas, which in turn may guide further learning design. Modern learning analytics can also be applied to develop learning personas. In addition, based on the current research design, psychological theory such as expectation value theory can be used and form a model based on factors such as engagement and academic achievement, testing the complex relationships between expectation value, engagement and achievement.

6.4.2 Different methodologies for similar studies: system logs plus critical interview

There are several ways to approach engagement, and one frequently used method is to use a self-reported questionnaire. The situational engagement in this study was based on an ESM approach that used interest, skills and challenge as preconditions for engagement. Self-report questions can be precise when no subjective felling is involved. However, it is suggested that future studies should include more dimensions of engagement data such as learning logs from learning management systems (LMS). In addition, to avoid subjective answers from students, a critical interview can be conducted right after the course, asking students why and how they answered the self-report questionnaires during the class. This, plus the learning logs, may provide researchers with more evidence of engagement levels and multiple ways to interpret each piece of available information.

6.4.3 Techniques for detecting engagement in situations

Besides thoughtful methodology design and enriched theoretical framework, future study could also take advantage of modern educational technologies. One such technology is eye tracking, a technology that grasps an individual's eye gaze on a computer display. Such technology assumes that one's visual 'focus' or facial expression can be used as a reflector of engagement across situations. It is worth mentioning that situational engagement evidence can also be found from the lens of neuroscience, in which physiological measures such as EEG, heart rate, blood pressure or galvanic skin response were measured, in order to access engagement level and alertness (Whitehill et al., 2014). However, those two approaches have one demerit: it is hard (i.e., in terms of cost and time) to apply them to larger samples, and it is recommended that such experiments be conducted in a joint effort with neuroscientists and phycologists. Still, such measures could provide interesting facts about students' engagement in different contexts. It would be one direction for future study on topics such as situational engagement and to provide detailed information on.

6.4.4 Learning support as an intervention

Designing an online course (or MOOC) is not about simply about moving all the materials used in classrooms onto an online platform; there are far more issues to consider. One such important aspect is learning support. Different from traditional classroom in which teachers, peers and even assistants were all present in the classroom, in an online learning environment, learners are basically connected with their teachers and peers via the Internet. An efficient learning support system can either provide immediate feedback on learning progress or solve problems that occur, such as technical issues. In addition, support and feedback from peers and teachers may lead to better online learning engagement once students have perceived the emotional and academic support as helpful.

In addition, never forget that content is the king. Well-structured course subject knowledge brings a better learning experience. As learned from this study, engagement can be better understood as a process (with ups and downs depending on the contexts or situations), thus course knowledge could be arranged in a way that provide enough challenge, but within students' control (in terms of skills). More importantly, the subject knowledge should be interesting, if students are constantly bored by the course, there is highly likely that they may drop out. It was also learned from the results that online learners tend to be highly situationally engaged at the beginning, but normally such engagement level was not maintained: It drops substantially in the middle and rises again in the later part of the course (see Figure 6-1). Therefore, it is arguable that interventions made in the middle part of course are necessary. For example, there is a need to provide interesting and challenging context once a while, to maintain learners' situational engagement, thus preventing earlier dropping out.

Undoubtedly, the role of teachers in a MOOC is also important. One aspect is that they should be well-equipped with Technological Pedagogical and Content Knowledge (TPACK) (Mishra & Koehler, 2006). That is, the integration of technological knowledge, content knowledge, along with good pedagogical knowledge, and the intersections between. Based on the TPACK definition, there are a few points to make. First, teachers or instructors should be aware of the process and approaches of participants' learning, know how to use the available information and community technologies to promote students' engagement. Second, teachers should be well-prepared and knowledgeable in the subject (i.e., in environmental science). For example, in this study it was found that students tended to engage more when the teacher spoke in a fluent, confident and relatively faster speed, this is also a feature of a well-prepared teacher. To engage students, the first step is for instructors to engage themselves. In addition, different and flexible pedagogical approaches should be used. According to the interview, students emphasized the importance of 'having choices' in terms of what to learn and when to learn, that is the autonomy. Based on self-determination theory, autonomy is one of the crucial factors that boost better learning engagement. A science MOOC could generate autonomy by providing learners with a range of choices in choosing learning modules, conducting evaluations or performing experiments.

In the field of education, most previous studies of online learning were conducted to investigate complex relationships between a student's motivations, engagement and academic performance, yet few paid attentions to the learning materials, or simply the quality of the course video. In this study, some effort was made to understand how contextual factors of the course video affect the learner's reported engagement, and in the interview, students were also asked what makes a good MOOC video. As a result, it was found that the role of teachers is of great importance. Besides having a clear accent in teaching and an appropriate speaking rate, the teacher should have his/her own style. Students generally like teachers talking with passion, while they dislike those who speak in plain, monotonous language and show no facial expression. In addition, teachers should plan carefully before recording a video lecture, including the video production style. Therefore, it is arguable that teacher engagement and course content are so important that it may contribute to students' engagement in online learning (Borup et al., 2014).

Looking back, there are few points to consider for future studies: First, subtitles can be useful in a course that not in the students' mother language. Students may need them or not, but they should have the choice to turn them off and on. Second, supporting course materials is important. Developing a 'learning resource bank' which contains course and materials were both relevant to and go beyond the current knowledge domain would be helpful. In the case of someone finding the content to be boring, they can always seek something more interesting to continue with. Third, it may also be interesting to figure out the role of feedback in a MOOC study. Future research could explore how different forms of feedback (i.e., feedback from peer, teacher, teaching assistants, or simply no feedback at all) affect student engagement in a boarder sense and also in specific situations.

7 RELIABILITY AND RESEARCH ETHICS

7.1 Validity

I tried to ensure the validity of this study. Two experts from the field of education were invited to review the instrument to be used, to ensure content validity. Feedback was collected and the instrument was adjusted accordingly. For example, based on suggestions collected from the expert group, one change was made to the *science attitude* variable, I found it would be better to interpret *attitude* according to personal interest, as the questionnaire items fit closely with feeling-related personal interest, and value-related personal interest. Structure validity was assured by conducting a series of exploratory factor analysis (EFA) using maximum likelihood method (with direct Oblimin rotation). Such a procedure enabled the researcher to explore if all items were perfectly located within each variable, items with poor loading were deleted from the dataset. For instance, on the *self-efficacy* variable, a careful EFA resulted in only an eight-item questionnaire, thus one was removed for further analysis.

The subject of this study was the contextually-dependent feature of situational engagement. The contexts, such as the content of the course, or the teachers' instructional styles, could all contribute to students' engagement levels. It is arguable that such features could be found in other subjects or in similar student groups. It is important to investigate contextual factors that contribute to students' learning engagement, learning activities can be rearranged and redesigned according to the knowledge of contextual factors. This is even more important for web-based learning environments, as the in-time remedy provided could prevent students from dropping out. This study also increases our knowledge that situational engagement is better treated as a process than a once-and-for-all status. Therefore, the results can be usable for both teachers and course managers tracking the learning sequence during online learning, and by doing basic analysis across a learning activity. Though this study covered a relatively small sample, it was conducted with care to ensure external validity. Firstly, the samples were selected randomly, and all participants were involved voluntarily. Secondly, both the survey and interview happened naturally: the survey was conducted in a normal science classroom, and the content of online course fitted closely with participants' science textbooks; the interview was arranged at a familiar and comfortable place. In addition, the author tried to describe the theory, key concepts, previous research in a clear manner, to report the procedure as precisely as possible. In the methodology part, details regarding data handling, analysis, and coding were presented with examples. Nevertheless, it is expected that similar results could be obtained from further studies.

7.2 Reliability

How did the research establish itself as trustworthy is another important issue? Before the actual data collection, a pilot test was conducted to know if the content, length of questionnaires was proper, and if the overall time allocation was enough for experiment. The pilot test was good as feedback collected from teachers and students greatly improved the final version of instrument. For example, it was learnt from the piloting that too many questionnaire items would affect students' learning flow. Thus some changes were made accordingly in the actual data collection. Meanwhile, the internal consistency was ensured since the similar instruments were used for both the pilot testing and actual data collection. In addition, in this study attention was paid to the stability of the questionnaires, since a similar instrument was administered to the same group of participants for actual data collection several months later. As a result, similar answers were gathered. In the dissertation write-up, I have described the methodological decisions and data analysis with care. For example, the data in this study were consistent with survey data and interview data. For easier reading, instruments and analysis methods were introduced separately, in a clearer manner. In the analysis of the quantitative data, Cronbach α was used as an indicator of inter consistency (or reliability), a common technique as used in a study with multiple scales. In the analysis of qualitative data, for better inter-coder reliability, a method like inter-rater agreement was applied: two raters first worked on the transcript of the interview independently, created initial codes and themes by using the thematic analysis method. After a certain degree of agreement (in this study, 83%), they then worked together for catalogues. However, as mentioned in the limitations section, because of the essence of a doctoral dissertation, the doctoral candidate conducted most of the analysis and decided which themes and catalogues were to be used in final dissertation.

7.3 Research ethics

In this study, I have tried to respect the principles of responsible conduct of research according to the ethical principles of research in the humanities and social and behavioural sciences (Finnish Advisory Board on Research Integrity [TENK], 2013). The research was planned and conducted with care. Early in the planning phase, methods applied for data acquisition, autonomy and privacy issues related to participants were discussed with the research group. The research permission was acquired from the faculty and the participating schools. In addition, the necessary parental (or guardians') consent was acquired, since most of the participants were below 18 years of age. Emails were sent to parents beforehand, informing them about the purpose and procedures of the study. For the interview, a permission was obtained from all participants before recording. The survey was conducted with help from schoolteachers, and teachers that assisted in data collection were contacted beforehand, making sure that all the materials used in the online course were appropriate and would bring no potential harm to the students. Before the data collection, students were all well-informed about the purpose of the study, and they could opt out of the course at any time they felt uncomfortable. The researcher also stressed the confidentiality of the information as supplied by the students. The data (both survey and interview) were stored, coded and analysed in a way that respected the students' anonymity. Based on my data management plan, the electronic and non-electronic data will be destroyed within three years of the publication of the doctoral dissertation. Finally, during the thesis writing up, the researcher paid attention to cite publications of earlier research appropriately, acknowledging their achievements, and reporting the results honestly and accurately.

8 CONCLUDING COMMENTS

Although studies on situational engagement are relatively rare especially in online courses, there is increasing interest among researchers in some domains such as in science education. Most of the current studies focused on situational engagement both within classrooms and in out-door learning environments. Usually, several key questions were asked. For instance, what makes students situationally engaged? Is (the level of) situational engagement context-dependent? How do we measure situational engagement? Researchers agreed that engagement is a changeable, malleable experience that occurs over time (Fredricks & McColskey, 2012). Therefore, measurements in real situations, such as using the ESM approach (Csikszentmihalyi & Schneider, 2000; Hektner et al., 2007), provides teachers and course designers with information on what makes science learning successful or attractive to learners. This study extended such an effort to the online learning environment. Using a short science MOOC on the topic of sustainable development, this doctoral study tested how contexts of online learning affect situational engagement as well as possible individual differences. From this study, it was found that value-related interest is the strongest predictor of situational engagement while self-efficacy is the second strongest. However, feeling-related interest failed to predict students' situational engagement. In addition, significant differences were found across all the situational measures, which again proved that situational engagement does not have a once-for-all status. Instead, it is better understood as a process that it may vary in intensity across different domains and situations or even sensible to styles of instructors.

Yet, there are more of such concepts to explore, and several questions remain unanswered. To begin, it is still hard to capture engagement in situations (properly) without disturbing students' learning flow. Probably new approaches and techniques need to be combined. Secondly, to date, science is among the limited subjects to be investigated moderately. The context-dependent features of situational engagement need to be confirmed in other domains and cultures whenever possible. For example, it may be necessary to investigate situational engagement in other STEM subjects, when considering that young people around the world are showing a declining engagement with the STEM fields.

In the measurement of situational engagement, (situational) interest was used as a precondition. This study also accessed the personal aspect of interest (including feeling-related and value-related interest) and how they explain situational engagement. The feeling-related interest, or enjoyment, has been extremely important in the learning environment. In the science domain, according to international programmes such as PISA (2015), young people's enjoyment of science is manifested in a declining trend. Such a trend is even more obvious in Finland. For example, the proportion of students who reported that they enjoy acquiring new knowledge in science shrank by more than 20 percentage points to about 50% (OECD, 2017). Therefore, maintaining young students' situational interest, and promoting it into a relatively stable personal interest in science, would seem to be crucial if we want to involve more students in the STEM fields. In addition, how various aspects of interest contribute to situational engagement, and how to make courses both interesting and challenging to learners, seem to be urgent problems.

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APPENDICES

Appendix A

Self-efficacy questionnaire

1. Compared with other students in this class I expect to do well.

2. I'm certain I can understand the ideas taught in this MOOC.

3 I expect to do very well in this class.

4 Compared with others in this class, I think I'm a good student.

5. I am sure I can do an excellent job on the problems and tasks assigned for this class.

6. I think I will receive a good grade in this class.

7. My study skills are excellent compared with others in this class.

8. Compared with other students in this class I think I know a great deal about the subject.

9. I know that I will be able to learn the material for this class.

Pre & post-test for science knowledge

1. Which of the following statements is false? (Select one)

a. Achieving sustainable development is only a technological issue

b. Environmentally friendly products can also be the cheaper alternative if you consider the lifetime of the entire product

c. Sustainable development is also a social issue and has important questions related to justice

d. Governments have an important role in reaching sustainable development by limiting consumer choices by legislation

2. This generation is... (Select one)

a. Consuming about as many resources as the planet can sustainably offer

b. Still consuming resources well within the limits of this planet

c. Consuming already more resources than the planet can sustainably offer

3. The resources of the planet are... (Select one)

a. Used quite equally around the planet

b. Industrial countries use a great deal more resources than developing countries

c. As developing counties do not utilize the best technologies, they use more resources per capita compared to industrial countries

d. Not an issue related to equality

4. 80 % of the CO_2 emissions come from… (Select one)

a. Burning of coal and natural gas for power production

b. Burning of coal and oil for power production

c. Burning of coal for power production and using oil for traffic

d. Burning of natural gas for power production and using oil for traffic

5. To achieve the global targets to limit climate change, by 2050, we need to… (Select one)

a. Reduce emissions by 80 % globally

b. Reduce emissions by 60 % in industrial countries

c. Reduce emissions by 60 % globally

d. Reduce emissions by 80 % in developing countries

5. Which of the following is true? (Select one)

a. Increasing renewable energies has the downside that their wide utilization is likely to reduce employment

b. The amount of wind and solar energy production has been very stable over the past few years

c. Today only a marginal portion of investments to energy go towards renewable energies

d. Renewable energies not only help in climate change, but they have positive societal aspects as well

6. Which of the following is false: (Select one)

a. The decision makers have been in an important role to guide user choices in the past and they are important role in the future

b. Innovations have been important in the past to use energy more efficiently and they are likely to be important also in the future

c. The future innovations are likely to come from the same fields as they have always come

d. There has been changes in in past regarding what is the most widely used source of energy and it is likely to change in the future as well

7. Regarding the energy consumption at home, which of the following statements is false? (Select one)

a. Heating and cooling can be the biggest energy consumers at home

b. Consumer behaviour cannot have an impact on energy consumption

c. The design of buildings has a major contribution on the energy use of the buildings

d. In general, the number of appliances in homes has continued to increase over time

8. Regarding Global energy consumption… (Select one)

a. Energy consumption in OECD countries is increasing

b. The use of fossil fuels is increasing

c. The use of renewable energy is increasing

9. Which of the following statements is false? (Select one)

a. Surplus heat from data centres can be utilized as an energy source, and thus, can be used to improve energy efficiency

b. District heating cannot utilize heat from industrial processes.

c. Waste heat can be collected from wastewater

d. Surplus heat from equipment, people and the sun can be collected from buildings and utilized as district heating.

10. Which of the following statements is false? (Select one)

a. Between 1990–2014, the number of refrigerators in OECD countries has more than doubled

b. Between 1990–2014, the energy consumed by refrigerators in OECD countries has increased around 50%

c. Between 1990–2014, the energy consumed by refrigerators in OECD countries has almost doubled

Appendix B

Interview protocol

INSTRUCTIONS

Good afternoon everyone. My name is Dong Yang. Thank you for coming. In this interview, you will talk in group, and share your opinions. The purpose is to recall your perceptions of your experiences in learning the previous online MOOC: Sustainable Energy. There is no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel.

TAPE RECORDER INSTRUCTIONS

If it is okay with you, I will be recording our conversation. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a report which will contain all students' comments without any reference to individuals.

INTERVIEW TOPICS (samples)

1. Is there any science related activity that you do in your spare time (i.e. movie, museum, book)?
2. If you recall the science MOOC experience, what are those you like and dislike?
3. How do you compare the science MOOC and the classroom teaching science?
4. Describe a time when you really enjoyed and concentrated on your task.
5. How important is science for you and for society?
6. Any suggestions for the MOOC?

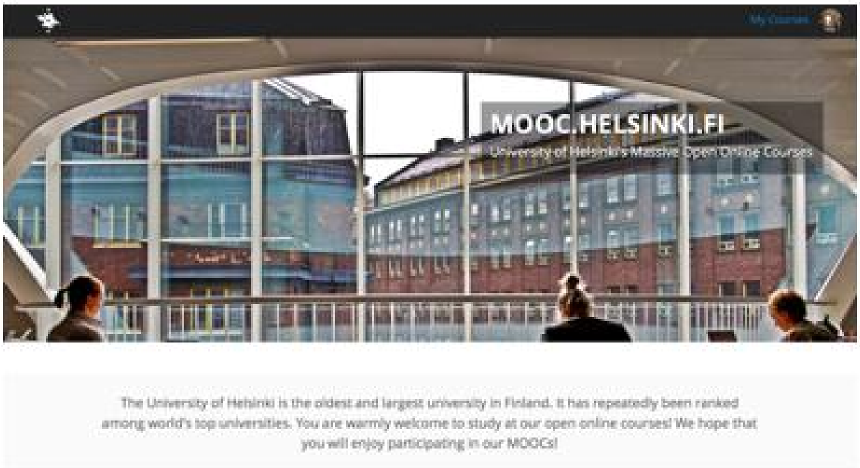
Appendix C

MOOC enrolment instruction

Step 1. find the MOOC platform via this link:

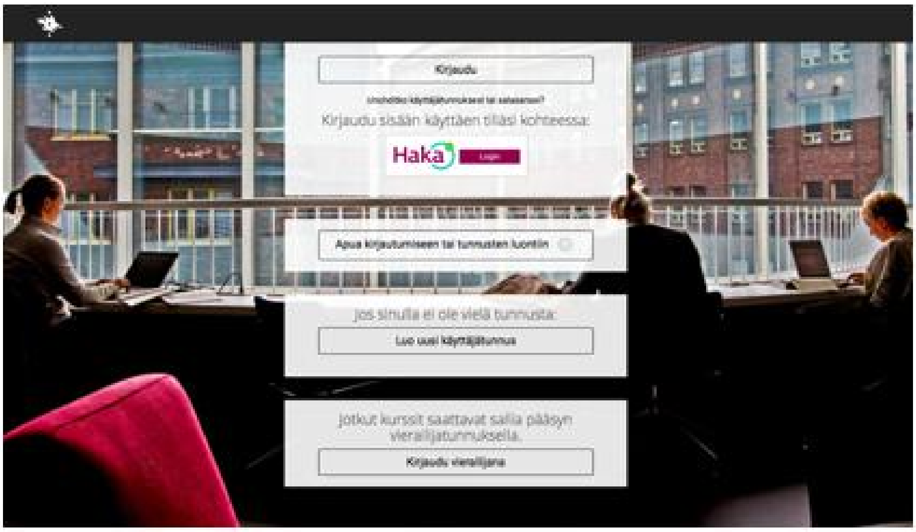
https://mooc.helsinki.fi/

It should look like this:



Step 2. At the bottom of the website, you can set the language you preferred.

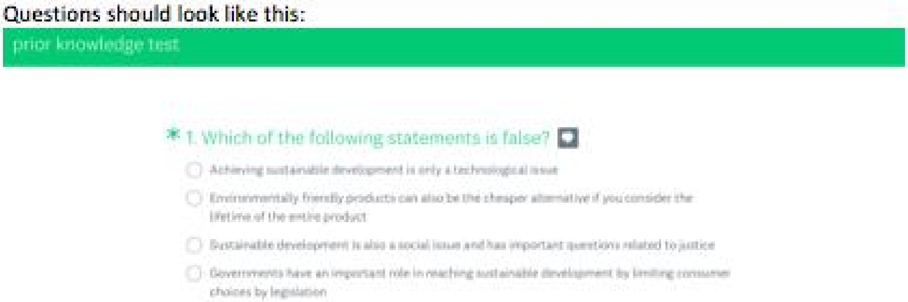
Step 3. Then you click "log in/kirjaudu", I guess most of you do not have an account, then you need to register an account by clicking "click new account/Luo uusi käyttäjätunnus".



Step 4. After you created a new account. Go to the "MOOC" page, choose "MOOC demos" and search " SEE2017_DongYang". Then you should find this MOOC.

Step 5, Once you find the MOOC page, you can start learning! Please remember at the beginning there are some questions, we just want to see how much you know. Thank you☺

Questions should look like this:



Appendix D

Tutkimus: Millä tavalla oppilaat kokivat asiantuntijaluennon osana luonnontieteiden opetusta

Arvoisa huoltaja(t),

Olarin koulun oppilaat ovat osallistuneet osana luonnontieteiden opetusta asiantuntijan pitämään verkkoluentoon energiansäästöstä/energiatehokkuudesta. Luento koostui kolmesta videosta, joiden kokonaiskesto oli 45 min. Puhe oli englanniksi, mutta videossa oli tekstitys suomeksi.

Videon katselun aikana opiskelijat vastasivat muutaman kerran lyhyeen kyselyyn, jotka liittyvät videolla esitetyn asian kiinnostavuuteen ja merkityksellisyyteen. Tällainen tieto on tärkeää, kun koulujen ja yliopistojen välistä yhteistyötä halutaan kehittää. Videon alussa ja lopussa on testi, joka mittaa oppimista videon alalla.

Nyt haluaisimme haastatella muutamaa oppilasta, jotta saisimme tietoa siitä, miten oppilaat kokivat videon.

Jos teillä on kysyttävää tutkimukseen liittyen, älkää epäröikö ottaa yhteyttä projektin johtajaan Jari Lavoseen. Olemme hyvin kiitollisia tästä mahdollisuudesta työskennellä yhdessä koulun X oppilaiden kanssa.

Toivomme teidän täyttävän alla olevan lomakkeen ja oppilaan tuovan sen kemian opettajalle.

Yhteistyöstä kiittäen,

Jari Lavonen,
Professori,
Helsingin Yliopiston Opettajankoulutuslaitos
+358 50 415 5317 (gsm)
jari.lavonen@helsinki.fi (e-mail)

- -

Minä ____ (Huoltajan nimi)

- Annan
- En anna

oppilaalle ____ (Oppilaan nimi)

luvan osallistua luonnontiedon opetusta ja oppimista koskevaan tutkimukseen.

Allekirjoitus, ____ (Huoltajan allekirjoitus)

Appendix E

Transcript of Semi-structured interview

H: So basically, all of you have went through this video during your science class, right?

S: Yeah...ah, yes.

H: Generally, how do you feel about it?

S1-11B: Well, those questions surprised me a little bit there, I didn't expect them to be too general, I was expecting something more specific, (related to the details of video content), that's my opinion…

H: Hmmm, ok. Yeah. Just say anything that comes into your mind, like the good aspects and bad experience, everything.

S2-08B1: I think the video quality, no, the sound quality was not that good, it was like had to turn my microphone really loud, like, I guess someone recorded this from the camera.

H: Yes, you point the sound effects.

S3-11G: Yeah, I think your video is quite good, the topic is quite funny, and also interesting, I learned a few things.

S2-08: Well, I watched the video with the lady in it (Part two - Energy Efficiency), I assume that she was kind of, I felt like bored and voice wasn't that interesting…

H: Oh, you mean the second part…

S2-08: The man (voice) was better; he was more interesting to me.

H: The man, ohm, you mean the last part (of video), and the lady from Helen, the energy company…So can I understand as: the man in video is more attractive to you?

S2-08B1: No, I mean the way they talk, the women is like talking in a steady boring tone. And the man was like, (a stop), hmmm, I'm sorry.

H: No worry, just take your time.

S2-08: It was like more interesting to hear the man talk.

S4-11B: Possibly the man is more enthusiastic…

S2-08: Oh, yeah…

S4-11B: Hmmm I think this is awkward to say, I didn't really get into the course. When I proceeded to the questions like *why are you here, and what you about this and that,* I almost did that, but I log out the course accidently and when I came back I forget my username.

H: You had a technical problem in this case.

S4-11B: I think I got really interested in the early stages, even though I didn't see the video.

H: Ok. (show them one part of the video, a kind of interview). Do you remember this part, those two in the video, they are a kind of interview, right? So normally when you have online courses, do you prefer this kind of interview, or normal instructor present and with PowerPoint behind him?

S1-11B: Well, just my opinion, I learn better if not like the interviewer, just like basic like presentation, for example.

S5-08B2: Yeah, same for me.

S1-11B: I get used to this, take teacher presentations for example, we have presentations that teacher always presents to us, she never has any interviews, so this is like little bit different and not usual for me.

H: Okay…

S3-11B: I think that's the same when I watch sometime like TED, there are specially that in a presentation, the one, he or she, not important, (smile) always points out something in PowerPoint, I think it's bit more interesting, this type of, like interview thing, is sometimes effective, but I think it's more effective when you try to learn language or something, but it works different for everyone.

H: I agree, I think in some typical areas or knowledge domains, the interview way can attract too much of your attention, like here (your attention) will change from this to this one (point to the video).

S5-08B1: Yeah, when there is a presentation, it doesn't matter if you get one person, two people or three people. You can see like nothing on the point they are talking about. You wonder alone and looking at the…(?)

S3-11G: You mean that sometimes just listening is difficult?

S5-08B1: Yeah. I like courses with no personal face, just content, and someone is talking at background. You can focus on the content and not the one who makes it.

H: Yeah, more? (To the girl)

S3-11G: Sometimes I find I also like, I remember some YouTube videos, like there's only the texts, or something like that, it also good way to do a video.

H: So, like if we have some choices in front. The first is this kind of interview way, the second is there a teacher presenting, and next to the teacher there's PowerPoint, the third one is only the text, and the background voice, so which one you prefer the best?

S5-08B1: Well. I prefer only text with only background voice. Because I can see the points they are trying to make, I can look at them as soon as they talk about it, I can look at it and hear about it.

H: How about you? (Point to Boy 2 from 8th grade)

S5-08B2: I get the same point on the presentation, you can watch too much at the presentation, you can't, like, if the voice is at the background, you can like…

S3-11G: I think I like the background voice thing on the picture or something, but then I think it's more difficult when the person is not speaking in Finnish, which is my mother language, so if it's in English, it's like sometimes more difficult to concentrate on. So, for me it's difficult when it's in English rather than Finnish…

H: Ok, that's a good point.

S3-11G: When it's in English or some other language, I prefer watch someone there with talk (interview/conversation).

H: Originally in the videos there were no subtitles, 'cos it's recorded for some international students also Finnish students, made by Faculty of Science. So, we put some subtitles, do you think it's good to have subtitles?

S3-11B2: Yeah, it's fine…

S3-11B1: I don't see like there's something bad about subtitles.

S3-11B2: Let me think, sometimes they argue that sometimes (subtitles) they do enhance the learning, like in languages, but not the point when we are talking chemistry or all the sciences. Even though English is the most used, or widely spoken language…

S3-11B1: Yeah, when it's for learning English, we don't have subtitles for that, there's no point for that then…

S3-11B2: Yeah, when we have for, maybe six years for, like chemistry in Finnish, it's really hard, maybe, to learn chemistry names, those are especially really, really hard, to do like learn them in Finnish, but then try to know them in English…Because they differ so much.

H: Yeah, I agree, we have a similar problem in China…

S3-11B1: That's no part of your attention, it's like just simple translation, when you try to learn something new, it affects your study…

S5-08B1: Like, there's different types of chemical acids, the words are like kind of similar in Finnish and English, when you heard those (words), it's this or it is that? It's kind of hard.

H: Yes. So, if we back to your daily life, do you read some books or watch some movies or, go to science museums, cos I know there's this science centre near the airport, right?

S5-08B1: Heureka.

H: Yeah, Heureka. So normally what do you do, like with books, movies or something else?

S3-11B2: LIKE, around science?

H: Yes.

S3-11B1: I am not like, that scientist man, cos I felt myself I got so much like I get so much in school already, so when I was in my free time, I watch some movies, I mean not always about science, because I just want have a free time…

S3-11B2: Well, maybe in the past, when I watched "*Math Master",* that was good science, I think most of us have watched, it got some, but they are really for the entertainment, not the science, but because we don't really remember anything from the science course.

S3-11B1: Yeah, I remember in the instruction part, only.

S5-08G: I have the science magazine delivered to my home, I try to read it, but it comes quite often that then I haven't found the time, that's quite sad, I would like to read more of them.

S1-08B1: Yeah, I subscribed to many sciences channels on YouTube, and I watch them…

H: Oh...

S1-08B1: I think that they are quite fun…and…

H: For example, I don’t know about that.

S1-08B1: Yeah, (discuss in Finnish…), it’s a course telling, hmmm, it’s an English Channel, which like make animations and everything about black holes, or the world in general, and, medicine, as such. …(is) very intensive, the one makes lot of physics videos, they are good and quite interesting.

S3-11-B2: I think I have similar experiences, even though I am not too (??), I just watch them from time to time, because they are really, really interesting.

S5-08B2: Yeah, that’s the same for me, I don’t subscribe to a lot of things, but I like to watch some science things.

H: Oh, you mean on TV?

S1-08B2: Yeah.

S4-11G: Hmmm, TV documentaries are also very nice.

S3-11B2: Yeah, especially there is the Finnish... it’s kind of, like open nature.

S4-08G1: Yeah, it explains about some animals which are not common in Finland. Like, for example, African, Amazon or something like that.

S3-11B2: Or focus on a certain type of animal, also are extra interesting, we watched them as a kid, it was really fascinating.

S4-08B1: When we watched the documentaries, you can’t see the face of a person who is talking, you can just relax and watch the video, instead of the (??) of a person.

S3-11B2: Since we had like similar (??)… for several years, it’s like we will use them…

S2-11B1: Maybe the best part for those videos, those science videos, that, you watch them in your free time, you know you don’t have to make a project out of it.

S4-11G1: Yeah.

S2-11B1: You don't feel like you have few to do after that.

S4-11G1: Yeah, like, you have to understand. It's not necessary.

S2-11B1: Nobody tells you that you had to watch it, you have to make like a paper…

S3-11B2: Yeah, like it's human nature, if we have, if you are forced to do something…

S2-11B1: We don't like…

S3-11B2: Yeah, we just like to progress ourselves, and we do anything else, even it will be educating ourselves with something completely different...

S2-11B1: Like if somebody forces me to go, it would not be same if I go there myself, on my own way. Hmmm, own choices.

H: I think this also applies to the situation when teachers ask you to, like as one part of the course, you need to go online, in order to get some credits… So you mean if you have more choices: Okay I don't want to do this now, maybe I can do it after the class, or I just want to see five minutes or ten minutes of this part to day, do you think it's, more like comfortable for you?

S3-11B2: Progressive learning is comfortable.

S4-08B1: But when you have a deadline, the next day turning in the evening, you like…(shrug☺)

S2-11B1: Like once we have one really "good" history teacher, she is a bit like a mean teacher in this school, because there are some jokes around school like she gives us a task to do with a ten-minute video, we have five minutes for it. This is like our teacher…

S3-11B2: This is like our experience with learning things. Then we have a class that, a year before us, there's a video about her: she's on the first slide of PPT, then the student gets to sleep. Then like for five minutes, then we are at 15^{th}, she's so fast…

S2-11B1: Also, somebody made about her, like when there's a bunch of students sitting there at the background, she's like (??), with pages that goes so fast, going, going, going…

H: Hmmm, I'm gonna ask you guys: if you gonna to take another similar video course as part of your study next time, compare with this one, what do you expect, by that I mean something new or different.

S2-11B1: Maybe those, I feel like those questions, if you really want to know what we have learned about this course or something, those questions should be specific, like more about the video (content). For example, you should turn off the lights, to reduce electricity.

H: Oh, you remember that.

S2-11B1: I do, so like there should be some questions about what you should do when you leave your home…

S5-08B2: Well, I can't remember much about the videos, so it was probably in my first chemistry class.

S4-11G1: You have made (learned) it quite a long time ago?

S1-08B1: Yeah, it was like one month, or one and a half months.

H: Even in March, did you guys did it in March?

S2-11B1: It's possible, maybe.

H: 'Cos also some students from, hmmm, Oulu they also did it.

S4-11G1: (Discussion in Finnish FOR A WHILE), I don't know, like they…

S1-08B1: We watched the video in March.

A period of chaos…

S3-11B2: Maybe we started in 5th period.

S5-08B2: We started the 4th period, the first class.

S3-11B2: But for us it was kind of DIY, we have so much else to do.

S2-11B1: Like we can't use our lesson time to…

S3-11B2: Yeah, unfortunately because this course of ours was just focusing on…

S2-11B1: You were not able to miss your course…

S3-11B2: Yeah, like you have, you are free from this course. We had to go to a university on a day, so you need to get this one free, so we had to…

H: I know.

S5-08B2: We have so many (??) to fill, too. So, we didn't have so much lessons…

S3-11B2: To focus on this topic, we have to do it ourselves, and you know what happens when you do it yourselves. Your progress, totally different…

H: 'Cos you have so many choices. How do you think about the difference, hmmm, if you do this, like for some parts of this period of science, if you do it totally online, or compare it with in the classroom setting, what would be the difference?

S2-11B1: Do you mean learning from the (online) video or learning from like school?

H: Yeah exactly.

S2-11B1: Well, when you are with teacher in the same room, there's a good part that you can ask the questions (in classroom) …

S1-08B1: You can talk within the classroom…

S5-08B2: You can ask your friends, also…

S3-11B2: In this (situation), you are pretty much "can", or if you are expecting to do it all by yourself at home, without your friends.

S2-11B1: Of course, there's good part which you can be (at) home when you are so far (from) your ??? and for example, just watch it.

S4-11G1: Yeah, I think like, I would like to say that, if I watch the video, I concentrate better, than like if (it's a) teacher, (I) start sometimes like oh, I don't have to listen so much...

S2-11B1: In video, a good part is if you didn't understand something, you don't have to ask from teacher, cos sometimes it can be embarrassing for you to ask…

H: Aha, the Finnish culture.

S2-11B1: So, you can choose like we want to (go back to) the video. You feel like if you ask those questions, or those (related) things, you are stupid.

S3-11B2: But, but now teachers are really encouraging (students to ask questions) …

S2-11B1: I know, there is also saying that: there is no stupid questions, but there's still like your background and idea of those questions…

H: How about you guys (point to rest of them).

S5-08B2: Probably videos sometimes are better because if you watch home some videos, you only want to watch, you concentrate on the topics, and if you had like headphones, you only concentrate on the video. In class, you have all the things around, you can't concentrate like friends talking or something…

S4-11G1: Yeah, sometimes I say also like a friend's gossip, he or she, the students talk about things, then when you are at home watching a video, there's (no) somebody else… Hmmm, interrupting you.

S5-08B2: Friends are like good and bad, you cannot ask them, or they are interrupting you.

H: Yes, like you guys talked about concentration. Sometimes I have had a similar experience, if I really like something, if like the teacher, or the course (itself) is good, when I do it really carefully, focus on it, I can totally ignore what happens around me…

S2-11B1: The one class can be like short…

H: Yeah, one class time can be (just) ten minutes for you. Looks like, I mean, time goes so fast. (Did you) have a similar situation when you do a task?

S3-11B2: Of course, of course. Especially when it's on the vulnerable side, maybe, because sometimes you just want, and you feel good.

S2-11B1: Sometimes like, for example, in this exercise week, you have it, I can notice that, when you don't have enough time, the times (goes) pretty fast, when you have too much time you have to wait for something, the time moves quite slow.

H: Yes, but, in terms of learning something, do you have the similar situation happens, ever?

S5-08B2: Yeah, it's interesting, like it's going faster…

S2-11B1: and when the class ends, you are like oh, god it ended already.

S3-11B2: Yeah, especially in the maths class, they end them so, so fast, cos you are focus on doing the exercise, mostly.

S1-08B1: I think physics is my favourite subjects in school. So, I just listen to the teacher and look at the books and learn about the things that we are supposed to do. It felt like in five minutes, the whole class is gone by. But for biology, that isn't like quite interesting, depends on teachers, also.

H: So biology is not interesting for you…

S1-08B1: No, no, it's not.

S4-11G1: I can give you an illustration of that, when I was in my junior high, like in my opinion, our religion teacher was amazing. I was thinking someone could say it was the most boring subjects in that school, but she made the lessons so entertaining, funny and, I was sad when she wasn't in the class, yeah we missed the class for school party or (activities). So, it was horrible (without her).

S2-11B1: We have here like some teachers I won't say the names. But for some teachers, I just personally don't learn from them sometimes, like I try my best to avoid their courses. But when I have to go to their courses, for example in the maths lessons… Yeah it depends on the teacher…

S3-11B2: Hmmm, one is fast, and one is not…

S2-11B1: With one teacher time went away like we have here (Finnish name) teacher, she is, in my opinion one of the best maths teacher. Yeah, if I say, good things about the teacher (it should be okay to speak the name out☺). But then there's some teachers I don't like, I don't understand what they say, and lesson was felt like it lasted for a very long time.

S3-11B2: Yes, it's really about If the teacher is enthusiastic about (things), also very good at explaining…

S1-08B1: Yeah, it really, if you have same topic, and have many options to choose which you learn it: one is like at homework, another is like in class, in class like much different options that you can learn about the subject, it really depends on teacher, the teacher makes such a big difference on that, the way you understand the whole thing.

H: So, you mean, the role of the teacher is (pretty) important for you to concentrate. And to (be) engaged in something.

S3-11B2: Yeah, extremely important when you got, hmmm, you can even, we can go back to the video thing, like we have the videos like there's only presentation and background voice, if the voice is, hmmm, in normal human sense, if you can sense that the person talking is really enthusiastic is much enjoyable than a person in monotonic voice. It doesn't make you feel right. You get bored, you don't want to listen the person doing in a monotonic voice.

S1-08B1: Yeah, it's really important that, like if a person is talking something not interesting, then you are not interested at all as well. Because it's like when a person like biology talks about maths, it's not interesting. But when a biology guy talks about biology, (when) it's super enthusiastic, the student learns so much.

H: I have one more question, before we finish this. Do you guys have any plans, like what you want to do for a job in the future, or, after graduation. It is quite far away, but you want to do something related to science, mathematics, engineering stuff?

S3-11B2: Yeah, I am really interested in the of job of chemist, like the one who makes plans for… (discuss in Finnish for a while), the lab worker, it was like a job… following the job but lab worker. It was extremely interesting, and I am so interested in chemistry and I got to see like atom things, how they research things, I got really interested in those things. And so now chemist job is into me.

H: Oh, you are interested in research stuff.

S3-11B2: Yeah, I love doing research, like do it myself, I don't know about my free time, but I love to do it. And I like to write down stuff. I like to do it, but a chemistry job is bit better paid than a lab worker, I have heard this…

H: How about you guys?

S1-08B1: Hmmm, I would like to be a physicist, or something, some jobs (related) to being a physicist. An architect would (also) be quite nice, but I can image like things that how they work, but I can't draw then…A literacy cats. My mind cannot do it with my hand. My hand is not working right, I can just image they are there.

S4-11BG1: I would like to become a doctor, something like that, maybe a surgeon.

S5-08B2: Well, I just know one such interest, kind of interest in many times types like, economist, or things like marketing director. I am only in 8th grade, so it can change on the way…

H: Yeah of course, and you?

S2-11B1: Well, I have my dream job could be eye surgeon.

S1-08B1: What?

S2-11B1: Eye surgeon.

S1-08B1: Ok, I heard ice surgeon.

S3-11B2: That would also be a good job.

H: That’s cool. Well, I think (that’s all), thank you guys so much. We are just talking like friends and…

S3-11B2: Thank you for coming…

H: Thanks, it’s my first time here, but it’s so beautiful around, I walked here from the 128 bus station near the bridge and walked all the way here; so picturesque! Thanks again, and I got so much from you guys. One last thing is: I brought you guys some small gifts…

Appendix F

List of tables

Appendix G

List of figures